Polar Prospects: A Minerals Treaty for Antarctica

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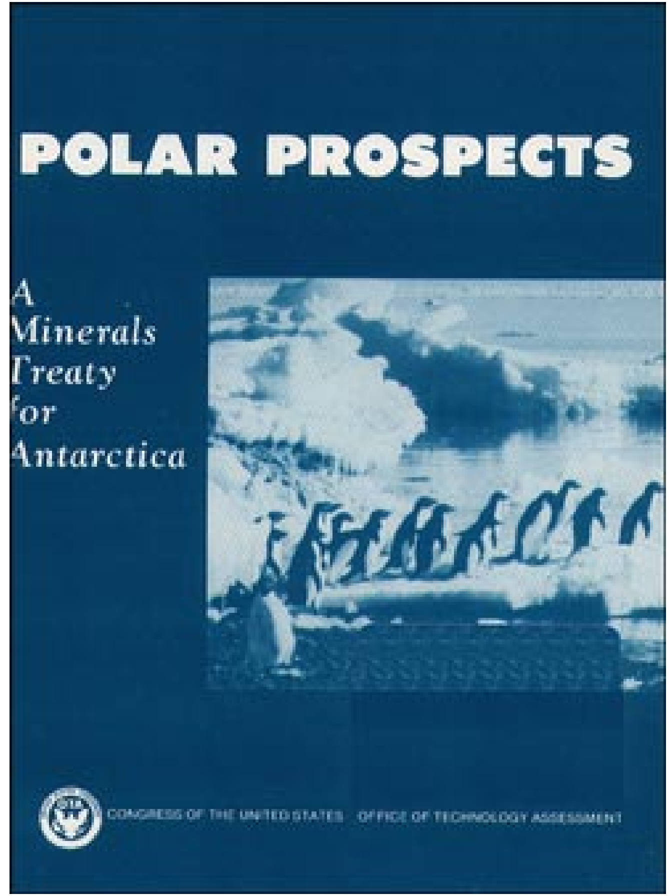

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Foreword

Few places remain on the Earth where rules for allocating natural resources and regulating their development are not at least reasonably well established. On land and within relatively narrow strips of adjacent coastal waters, dominion over resources-and thus the power to allocate and regulate-is largely settled. Although not universally accepted, general rules have even been established to regulate any future mineral exploitation of the deep seabeds, the vast ocean areas beyond national jurisdiction. Antarctica, by virtue of extreme isolation and a unique political history, is the last major area of the world without some system of governance for mineral resource activities. Rules establishing such a system, *although not yet in force, are* embodied in a new treaty, the 1988 Convention on the Regulation of Antarctic Mineral Resource Activities. The treaty does not presume that minerals will ever be developed in Antarctica. Rather, it establishes a framework for considering whether activities may be allowed and for regulating any activities that are permitted.

Four committees of the Congress, the Senate Committees on Foreign Relations and on Commerce, Science, and Transportation, and the House Committees on Foreign Affairs and on Merchant Marine and Fisheries asked OTA to evaluate the implications of this new treaty for the United States. The Senate has a constitutional responsibility to give its advice and consent to ratification of the treaty. Both houses of Congress will have to pass legislation to implement the treaty should it be ratified. OTA's report on the Minerals Convention is intended to provide a timely and useful reference to the Congress as it considers these topics.

This report identifies U.S. interests in Antarctica and evaluates the Minerals Convention relative to these interests. It examines the status of knowledge about the resources of Antarctica, the potential impacts of minerals development, and the technical, economic, environmental, geological, and political constraints to development in Antarctica.

We received substantial assistance from many individuals and organizations in the course of this study. Special thanks go to OTA's Antarctica Advisory Panel; to participants in the three workshops convened during the study; to the project's contractors; and to experts in the National Science Foundation, the Department of State, the Department of the Interior, the Marine Mammal Commission, and the National Oceanic and Atmospheric Administration. We also gratefully acknowledge our sister congressional agency, the Congressional Research Service, for again sharing its expertise. However, OTA remains solely responsible for the contents of this report.

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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

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Photo credit Ann Hawthorne

Argentina Range

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SUMMARY

Antarctica, home to penguins, seals, and whales and long of interest to explorers and scientists, is under increasing scrutiny as a potential source of valuable minerals. **Although little is currently known about Antarctica's mineral resources and no mineral deposits of commercial interest have been discovered yet, the potential that a discovery may be made is increasing.** Moreover, the 1959 Antarctic Treaty, the basic agreement governing the continent, did not establish guidelines for mineral resource activities. As a result, the United States and other Parties to the Antarctic Treaty launched negotiations in 1981 leading to the conclusion of the Convention on the Regulation of Antarctic Mineral Resource Activities in 1988.

The Convention on the Regulation of Antarctic Mineral Resource Activities would provide a framework to guide future decisions on whether Antarctic minerals should be developed, and if so, under what circumstances. While the Convention would establish rules governing minerals development, it does not presume that any exploration or development will ever take place.

Like virtually all treaties, the Minerals Convention is a compromise agreement. It took 7 years to negotiate and brokers the interests of claimants and nonclaimants, of developed and developing countries, and of countries with interests in mineral resources and countries mainly concerned with the environment. Alternatives to the Convention include declaring Antarctica off limits to any minerals activities. Given the history of Antarctic claims, the multilateral nature of the negotiation, and the conflicting interests at stake, **it is doubtful that a fundamentally different compromise could have been negotiated.**

For over three decades, the United States has advanced four main interests in Antarctica: maintaining the region as a zone of peace, preserving the freedom of scientific research, protecting the environment, and preserving an opportunity for U.S. industry to develop Antarctic resources if and when it becomes feasible to do so.

If a major minerals discovery is made in the absence of an international agreement about Antarctic minerals, an unregulated "gold rush" could follow, unraveling the Antarctic Treaty System and damaging all U.S. Antarctic interests. The Minerals Convention would help maintain the continent's longstanding peace and stability. It would enable consideration of mineral resource activities. And, although some environmental groups would prefer banning all minerals development in Antarctica, the Convention is one of the strongest international environmental protection agreements negotiated to date. **OTA concludes that ratification of the Minerals Convention would advance U.S. interests.**

OTA does not expect that either an oil deposit or metal mine would be developed in Antarctica sooner than about three decades, if ever. Geologic, economic, environmental, and political constraints to minerals development there currently are substantial. A commercial oil or hard mineral deposit in Antarctica would have to be of world-class size and quality to be developed economically. Probably only a handful of such undiscovered resources are left in the world.

Any development that does occur will inevitably cause local environmental impacts. More

[1] Hereinafter referred to as the "Minerals Convention," or, more simply, as the "Convention."

significant impacts might result from a major oil spill. Even the strong environmental standards established by the Minerals Convention—including the provision that no exploration or development is to be allowed until technology and procedures are available for safe operations—cannot guarantee prevention of all development-related accidents.

U.S. ratification of the Convention does not presume that the United States will sponsor prospecting, exploration, or development. However, if the Convention enters into force, the United States will have to decide which agency or agencies will represent it in Convention institutions. As well, domestic implementing legislation should address the need for a regulatory structure to manage any minerals activities the United States may sponsor.

Domestic legislation should also address the data and information needs that are likely to grow if U.S. minerals-related activities increase. Even if the United States does not itself sponsor such activities, environmental baseline data will be required to help the United States effectively monitor activities of other nations and to participate influentially in the Convention's institutions.

Because the United States may expand environmental data gathering, monitoring, and minerals reconnaissance and would need to regulate any Operators it sponsors, the Congress should consider institutional arrangements for future U.S. Antarctic activities. The present approach, which assigns primary authority to the National Science Foundation, may serve adequately. Or, Congress could consider granting responsibility for minerals activities to the Department of the Interior, the National Oceanic and Atmospheric Administration, or perhaps to a small Minerals Commission or a new U.S. Antarctic Agency.

Applied research needs related to potential minerals activities do not at this time appear to be more important than the basic research that has been the focus of the U.S. program under the Antarctic Treaty. However, modest funding for data acquisition would help advance long-term U.S. interests; cooperative projects among Parties to the Minerals Convention would help reduce the high costs of both applied and basic research.

Before exploration and development may be considered in Antarctica, a supplemental agreement on liability must be negotiated. The U.S. Senate must consider whether to give its advice and consent to ratification of the Minerals Convention before the Liability Protocol is negotiated or wait until it has been finalized.

INTRODUCTION

Antarctica has intrigued mankind for more than two centuries, certainly at least since Captain James Cook attempted to prove the existence of the southern continent as part of his second great voyage beginning in 1772. Speculation about the possibility of finding valuable resources in Antarctica began early. However, until recently the practicality of developing mineral resources in this coldest, stormiest, and most isolated land mass on Earth seemed too farfetched to deserve serious consideration. Mineral resource development in Antarctica is probably about three decades away under the most optimistic scenarios, and it may possibly never occur. Still, the countries most involved in Antarctica (the signatories to the 1959 Antarctic Treaty) determined in the mid-1970s that it eventually would be necessary to negotiate a regulatory framework for managing mineral resource activities there. In 1981, after they had concluded an agreement for regulating exploitation of marine living resources, they began to negotiate a minerals regime.

On June 2, 1988, after a 7 year effort, the United States and 32 other nations completed negotiation of a treaty to regulate possible future prospecting, exploration, and development of oil and other minerals in Antarctica. The treaty, known as the Convention on the Regulation of Antarctic Mineral Resource Activities, provides a framework for determining what, if any, minerals exploration and development will be allowed to take place in Antarctica and for regulating any minerals activities that are permitted. **Before the Convention can take effect, however, it must be ratified by at least 16 members of the subset of participants to the Minerals Convention who have special interests and responsibilities in Antarctica.** The United States, long one of the most active and influential countries in Antarctica, is a prominent member of this group, known as the Antarctic Treaty Consultative Parties (ATCPs). Additional members include the other original signatories of the 1959 Antarctic Treaty and 10 more recent signatories that currently conduct research in Antarctica.[2] The United States also is one of nine countries that, individually, could determine the fate of the Minerals Convention: **If the United States, the Soviet Union, or any one of the seven countries with territorial claims in Antarctica do not become a party to the Convention, it will not enter into force. However, ratification by the United States could encourage others to do so.**

This assessment addresses the questions surrounding whether the United States should ratify the Minerals Convention, and, if it does, how the Federal effort could be organized to address the needs created by U.S. ratification. Central **to this study** is the description and analysis of the Minerals Convention in chapter 3. The Convention, and specifically implications of ratifying or not ratifying it, cannot be completely understood in isolation, so chapter 2 presents a brief history of the United States in Antarctica, a review of current U.S. interests, and a summary of why the United States and other countries decided to negotiate the Minerals Convention. Chapter 4 describes the mineral resource potential of Antarctica, and chapter 5 describes the environmental impacts of minerals activities. The status of technologies for exploiting Antarctica's mineral resources and a brief discussion of the economic feasibility of development are in appendixes A and B. The complete texts of the Antarctic Treaty and the Minerals Convention are included as appendixes C and D, respectively.

This first chapter summarizes OTA's findings and presents several options for organizing the Federal effort in Antarctica if the Minerals Convention is ratified. The United States has a strong interest in preserving the Antarctic Treaty System. The Minerals Convention supplements and strengthens this unique system of governance. Its entry into force would help ensure that Antarctica remains peaceful and demilitarized and that the current spirit of cooperation among ATCPs prevails. **The Minerals Convention is not intended to, and does not, promote Antarctic minerals development. Equally it does not ban minerals development altogether.** Rather, it sets out a framework of standards and principles (including stringent environmental standards) with which any *permitted* activities must comply and establishes institutional mechanisms to evaluate proposed activities. Although not completely satisfactory to either commercial or environmental interests, the Convention, OTA finds, strikes a workable balance between environmental protection and resource development.

It is unforeseeable whether Antarctic minerals will ever be developed: however, several nations will continue to conduct geological and geophysical research that may lead to a discovery. Political, environmental, geologic, economic, and technological hurdles to minerals development will continue to be significant. Technological hurdles may be the least difficult to overcome. By establishing a framework regime, the ATCPs have taken a large step toward ensuring that minerals questions do not become a source of conflict and, hence, that Antarctica is maintained as a zone of peace.

[2]The total number of ATCPs is now 22; an additional 17 states are signatories of the Antarctic Treaty. Thirty-three states attended the final meeting of the Minerals Convention. A complete list is given in ch. 2, p. 25.

THE CURRENT REGIME AND UNITED STATES POLICY FOR ANTARCTICA

Antarctica is the only continent with no commonly recognized national boundaries. Seven of the Antarctic Treaty Consultative Parties (ATCPs) have made claims to parts of Antarctica, of which three overlap.[3] Neither the United States nor any other nonclaimant country has recognized these claims. However, both the United States and the Soviet Union have reserved the right to make future claims in Antarctica based on their historic activities. **The lack of an agreed legal status for Antarctica is a key consideration in any effort to manage activities on the continent.** To date, governance has been achieved through negotiation and consensus, not exclusive sovereign control. This unique regime was established by the Antarctic Treaty and applies to the area south of 60 degrees south latitude (figure l-l).

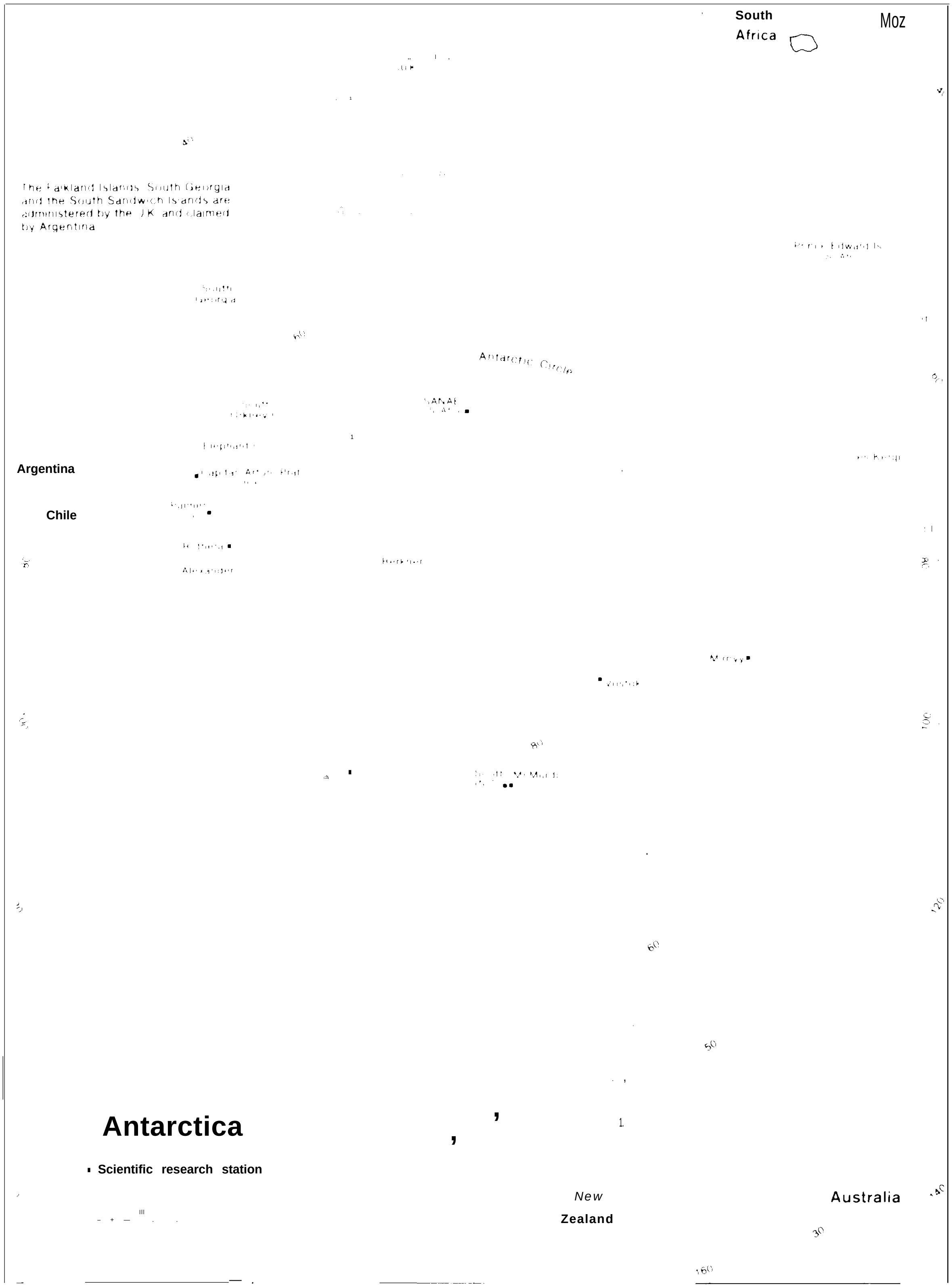
The Antarctic Treaty emerged in the wake of the 1957-58 International Geophysical Year, during which scientists from 12 nations established research stations throughout Antarctica and, in the process, developed cooperative relationships that both scientists and diplomats felt should be continued. In negotiating the 1959 Treaty, the 12 original parties pledged to use the continent for peaceful purposes, established an inspection system, and froze the dispute over claims. Claims would neither be accepted, denied, qualified, nor clarified; instead, the claims issue was sidestepped. They also agreed in the treaty that freedom of scientific research would continue, and that research plans, personnel, and results would be freely exchanged; that there would be neither nuclear explosions or weapons testing of any kind nor disposal of radioactive wastes in the Treaty area; and that ATCP-designated observers would have free access—including aerial observation—to any area and could inspect all stations, installations, and equipment.

The Antarctic Treaty, while limited in its objectives, is a highly successful multilateral agreement. The Treaty has fostered cooperative activity in Antarctica and has kept it demilitarized for the nearly 30 years since its inception in 1961. One of the Treaty's limitations (although it did not seem important at the conclusion of negotiations in 1959) is that it does not address the ownership or regulation of Antarctica's mineral resources. However, in the past ATCPs have been able to respond to issues when it has become important to do so, and, under the auspices of the Antarctic Treaty, have agreed on a number of additional measures regulating activity in Antarctica. For instance, environmental concerns were initially addressed in the 1964 Agreed Measures for the Conservation of Antarctic Fauna and Flora. These conservation measures prohibited the killing, capturing, or molesting of any mammal or bird native to Antarctica without a permit. They also established the basis for creating Specially Protected Areas.

Over the last 17 years, three additional conventions have been added to create what is now commonly known as the Antarctic Treaty System (ATS). In 1972 the Convention for the Conservation of Antarctic Seals, which sought to prevent the overexploitation of seals, was adopted. It entered into force in 1978. The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR—see ch. 5) was adopted in 1980 and entered into force in 1982 as a means to foster conservation and prudent management of the living resources of the Southern Ocean, particularly Antarctic krill and finfish. The 1988 Minerals Convention is the most recently negotiated agreement. Unlike

[3] The seven claimant states are Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom. The claims of Argentina, Chic, and the United Kingdom overlap.

Figure I-I—Antarctica



Antarctica covers an area of about 5.4 million square miles, making it the fifth largest continent. About 98 percent of Antarctica is buried beneath a thick continental ice sheet.

SOURCE U S. Government, 1982

the Antarctic Treaty and CCAMLR, its decisionmaking procedures do not always rely on consensus.

The United States has four fundamental interests in Antarctica:

1. **maintaining the region as a zone of peace,**
2. **preserving freedom of scientific research,**
3. **preserving the Antarctic environment, and**
4. **providing an opportunity for U.S. private industry to exploit Antarctic resources if and when it becomes feasible and appropriate.**[4]

The United States has an interest in promoting political stability in the region, so the region does not become, in the words of the preamble to the Antarctic Treaty, ''the scene or object of international discord. There is, of course, some inherent tension among all these U.S. interests. Should minerals development commence, the tension between exploitation, environmental protection, and scientific research can be expected to increase. To further these interests during the past 30 years, the United States has striven to become an influential force in all elements of the Antarctic Treaty System.

Since 1965 U.S. Antarctic policy has been coordinated and managed by the Antarctic Policy Group (APG), an inter-agency task force established by a directive from President Johnson. It includes representatives of the Secretary of State (chairman), the Director of the National Science Foundation (NSF), the Secretary of Defense, and of other agencies as appropriate. On February 5, 1982, President Reagan issued a policy memorandum essentially reiterating long-standing U.S. policy that the U.S. Antarctic Program (administered by NSF's Division of Polar Programs) would be maintained "at a level providing an active and influential presence in Antarctica designed to support the range of U.S. Antarctic interests. ' Important means for realizing these interests have been promotion of international scientific cooperation and continued efforts to strengthen the Treaty System. This "presence'' includes the conduct of scientific research in major disciplines; year-round occupation of the South Pole and two coastal stations; and maintenance of a continent-wide logistics capability. The NSF has primary responsibility for budgeting, logistics, and support of scientific research. The National Oceanic and Atmospheric Administration (NOAA) was directed in 1984 (under the Antarctic Marine Living Resources Convention Act) to fund and conduct directed research projects related to the marine living resources of Antarctica.

THE CONVENTION ON THE REGULATION OF ANTARCTIC MINERAL RESOURCE ACTIVITIES

Why Was the Minerals Convention Negotiated?

Until relatively recently, there was little perceived need to establish rules for regulating the exploitation of nonliving resources in Antarctica. Antarctica is isolated and among the most difficult places in the world to operate. During the 1970s, however, a combination of scientific, technological, and political factors began to change perceptions of Antarctica's mineral resource potential and to increase Antarctic Treaty Consultative Parties sense of urgency about developing a minerals regime.

The ATCP's negotiated an agreement governing the possible future exploitation of Ant-

[4] U.S. Antarctic interests have been discussed in ''The U.S. Antarctic Program,'' a report submitted by the Office of Management and Budget to the Committees on Appropriation of the U.S. Senate and House of Representatives, May 1983. See also, David A. Colson, Assistant Legal Adviser, Department of State, ''The United States Position on Antarctica, " *Cornell International Law Journal*, vol. 19, No. 2, Summer 1986, pp. 291-300, and *Antarctica, 1984*. Hearings before the Subcommittee on Science, Technology, and Space of the Senate Committee on Commerce, Science, and Transportation. 98th Cong., 2d sess. Statement of R. Tucker Scully, Director, Oceans and Polar Affairs, Department of State. pp. 7-9.

[5] White House Memorandum 6646, United States Antarctic Policy and Programs. Feb. 5, 1982.

Pbto credit. US Geological .%fV@y

McMurdo Station on Ross Island, the main U.S. research base in Antarctia Observation Hill is in the background.

arctic minerals for a number of interdependent reasons. The Antarctic Treaty itself is silent about regulation of mineral resource activities. This posed few problems in the first two decades of the Treaty's existence. However, scientific study of the continent has caused what was virtually terra incognita in 1959 to become geologically better known by the early 1980s. Occurrences of minerals have been found which, if discovered in large and rich deposits, could attract commercial interest. In addition, technology to exploit resources has improved. Although such technology has been developed for use in other regions, some of it could be adapted to recover offshore hydrocarbons or to mine Antarctic minerals.

As early as 1%9 several ATCP governments received inquiries from companies interested in geophysical oil prospecting offshore. Both the dramatic rise in oil prices in 1973 and scientific drilling in the Ross Sea stimulated further commercial interest. (The Ross Sea drilling did not necessarily indicate an oil or gas deposit.) No agreed procedures were in effect at the time to authorize prospecting, and the governments which were approached believed that if they allowed their nationals to prospect, they could upset the stability of the ATS. In 1977 the ATCPs adopted a recommendation urging voluntary restraint on ''exploration and exploitation' conditional on progress toward a minerals regime. Over the years both claimants and nonclaimants alike had developed a strong stake in the preservation of the ATS.

From 1972 on, Antarctic mineral resource discussions became a regular item on the agenda of ATCP meetings. At their eleventh meeting in Buenos Aires in 1981, the ATCPS formally decided to negotiate a minerals regime for Antarctica. As negotiations got underway in 1982, separate negotiations to establish the United Nations Convention on the Law of the Sea were winding down. Some in the United Nations questioned the legitimacy and effectiveness of the ATS and proposed that Antarctica be considered in a broader international forum as ocean issues had been. Because of their active involvement in Antarctic activities, ATCPs have long held that they possess special interests and responsibilities in Antarctica, and that they manage a legitimate international legal system for the continent. They have therefore resisted all attempts to transfer authority over Antarctica to the United Nations. Indeed, heightened U.N. interest in Antarctica provided the ATCPs additional motivation to conclude negotiations already underway.

How Does the Convention Work?

The Minerals Convention provides a framework for determining the acceptability of mineral resource activities and for regulating any activities determined to be acceptable. The 67 main articles and 12 annex articles of the Convention establish the general principles, specify the legal obligations of the Parties, and create the institutions and procedures necessary for decisionmaking. No **minerals activity is to take place except in accordance with the Convention and unless significant environmental impacts can be avoided.**[6]

[6]Arts. 3 and 4.

Of necessity, the Minerals Convention is a carefully crafted compromise agreement Negotiators had the difficult task of dealing with the reality of the differing juridical positions of claimant and nonclaimant countries. They also had to try to balance the interests of the developed and developing states among the group, of states with free market and centrally planned economies, and of states stressing environmental protection versus states stressing a regime that would facilitate minerals development activities. In addition, the value of Antarctica for other uses, such as science, tourism, wilderness, and the harvesting of marine living resources had to be given appropriate weight. Hence, the Minerals Convention is complicated, even though it provides only a framework and not a complete and detailed code for regulating mineral resource activities.

The Minerals Convention would establish five institutions: a Commission, Regulatory Committee(s), an Advisory Committee, a Special Meeting of Parties, and an Arbitral Tribunal, plus a Secretariat to serve all five. The Commission and any Regulatory Committees established are the only decisionmaking institutions.[7] The Commission includes ATCPs and any other Parties actively engaged in resource activities or related research. It has broad authority for determining whether and where mineral resource activities may take place and for establishing general rules and procedures applicable to all minerals activities. The details of regulating these activities will be worked out after entry into force of the Convention and when and if interest is expressed in such activities. The Commission is also charged with determining the composition of Regulatory Committees and may review some of their actions.

No **exploration or development would be allowed unless specifically authorized by the Commission.** One of the Commission's most consequential decisions will be to decide whether to allow consideration of exploration and development in specific areas. This threshold decision to ''identify"8 an area would trigger a process that could ultimately result in developing a deposit. **Such a decision would require a consensus of all (presently 22) Commission members and must be based on adequate data and information.** Reaching consensus among this many diverse parties on such an important decision may well be very difficult.

If the Commission decides to identify an area of Antarctica for exploration and development of a particular mineral resource, a Regulatory Committee for that area would be established. Regulatory Committees would be comprised of a total of four claimant states and six nonclaimant states, and would in all cases include the United States, the Soviet Union, and the relevant claimant(s) (if any) in the area identified. States conducting approved activities in the area would also become members. Regulatory Committees would be responsible for specifying detailed requirements for exploration and development of the area. These requirements would have to be consistent with any general guidelines established by the Commission, but the Regulatory Committees, and not the Commission, would be the primary managers of any development activities in their respective areas.

The Scientific, Technical, and Environmental Advisory Committee will give expert advice to the Commission and Regulatory Committees on all scientific, technical, and environmental aspects of minerals resource activities. One of the most important functions of the Advisory Committee is to evaluate environmental and technical assessments of proposals to 'identify" areas and of plans for exploration and development. Membership is open to all Parties to the Minerals Convention, but the Advisory Com-

[7] The Arbitral Tribunal can only render decisions for disputes referred to it.

[8] This is the term used in the Minerals Convention to refer to opening an area for possible exploration and development.

mittee has no independent decisionmaking power. Likewise, the Special Meeting of Parties, whose function is to advise the Commission on whether identification of an area for exploration and development is consistent with the provisions of the Minerals Convention, has no independent decisionmaking power.

Some groups are concerned about the relative power of the Commission and Regulatory Committees, as well as the lack of decisionmaking authority of the Advisory Committee. Groups opposed to development prefer that most power be vested in the Commission where more votes are required to take any action. They mistrust the smaller Regulatory Committees, which, they believe, would have a greater interest in accommodating development. Some countries (i.e., developing and nonconsultative parties) preferred vesting the Commission with more authority so that they could play more of a role in decisionmaking. Pro-development groups,[10] conversely are concerned that the Commission has too much power. Also, the claimant states preferred that Regulatory Committees be allocated substantial decisionmaking power. **The checks and balances built into the institutions, including their composition and voting procedures, as well as the authority of each, reflect the compromises that were necessary to achieve a mutually acceptable agreement in a complex, multilateral setting.** The United States and the Soviet Union will be represented on all Regulatory Committees as well as on the Commission.

Resource activities are divided into three distinct phases in the Minerals Convention: prospecting, exploration, and development. To engage in any of these activities, a potential developer (an 'Operator' in Convention terms) must be sponsored by one of the Parties to the Convention. Sponsors must evaluate and certify the fitness of Operators and oversee their activities to ensure their compliance with the Convention. Sponsors that fail to ensure that their Operators are able to meet Convention obligations could incur liability for damages. Sponsoring States must also support and defend the interests of their Operators in institution meetings. If the United States decides to sponsor minerals activities, it must prepare to regulate Operators that may apply.

Prospecting is subject to the same standards as exploration and development, but oversight of prospecting is primarily the responsibility of the Sponsoring State. Prospecting as defined in the Convention is not normally expected to have a significant or long-lasting impact on the environment. Exploration and development-if allowed in specific areas—would be regulated in accordance with detailed prescriptions and more extensive oversight by the institutions, in addition to that by the Sponsoring State.

Once an area is "identified' and the Regulatory Committee established for that area determines specific application requirements, an Operator would be required to obtain an exploration permit. Permission to explore must be based on information adequate to enable informed judgments to be made by the institutions. The permit is granted if two-thirds of the Committee members (which must include majorities of both claimants and nonclaimants on the Committee) approve the application. Successful applicants are granted exclusive rights to explore for a specific resource, subject to specific terms and conditions of a Management Scheme (i.e., contract). The Operator is also granted an exclusive right to develop any deposits found, but this right is subject to review after the development application (which requires a complete description of development plans) is submitted. Modifications to the development plan may or may not be requested by the Committee. There are conflicting interpreta-

[9] For example, the Antarctic and Southern Coalition, an environmental umbrella group

[10] For example, the American Mining Congress and the American Petroleum Institute.

tions as to whether development is automatically approved if the requisite majority in the Committee cannot agree about what modifications are necessary or if there must be positive agreement on modifications before development may proceed. The details of this process are described and evaluated in chapter 3.

Before it can enter into force, the Minerals Convention must be ratified by 16 of the 20 founding ATCPs.[11] Moreover, before any exploration and development can take place, a number of conditions must be met. Significantly, the details of a liability system must first be negotiated and ratified in a separate protocol (see page 33). In addition to the sufficiency of information requirements noted above, the environmental standards must be met and technology and procedures must be available for safe operations and for compliance with environmental regulations. There must also exist a capacity to monitor key environmental parameters and ecosystem components and to respond effectively to accidents.

RATIFICATION CONSIDERATIONS

The United States Constitution states that the President "shall have Power, by and with the Advice and Consent of the Senate, to make Treaties, provided two-thirds of the Senators present concur. . . " Thus, the Senate must pass judgment on whether completed treaties should be ratified by, and become binding on, the United States.[12]

U.S. ratification of the Minerals Convention involves consideration of many questions, but they seem to boil down to 4 basic concerns:

1. Is the United States better off with or without this agreement?
2. Does the agreement advance U.S. interests?
3. Are there different types of agreements that would be better than the Minerals Convention?
4. Can the provisions of the existing agreement be made more satisfactory if we choose not to ratify it in its present form?

Is the United States Better Off With the Minerals Convention or Without It?

The consequences of not ratifying the Minerals Convention depend in part on whether an oil or mineral deposit that is, or could become, economically exploitable is found in Antarctica. If none is discovered, failure to ratify the Minerals Convention probably will not have significant economic or environmental implications. Political implications, however, could still be significant because the inability to reach agreement would portend a weakening of the ATS.

Despite their varying attitudes about the desirability of developing Antarctic minerals, ATCPs have concluded a framework regime to make later decisions as to whether any part of Antarctica shall be opened for exploration or development. Hence, although some environmental groups have sought to ban any minerals activities, ATCPs declined to take such action.

If the Convention does not enter into force and countries have not otherwise prohibited all resource development in Antarctica, the unclear legal status of Antarctic minerals may deter potential investors from risking large sums of money on exploration and development. Hence, a significant discovery may be less likely if the Convention is not in force. However, scientists could make a major discovery in the course of their research there. So could other parties engaged in prospecting thinly veiled as research. If a major deposit is discovered and the Conven-

11 See ch. 3 for details, table 3-1, p. 60.

12 Congressional Research Service, Library of Congress, "Treaties and Other International Agreements: The Role of the United States Senate," a study prepared for the Committee on Foreign Relations, United States Senate (Washington, DC: U.S. Government Printing Office, 1984).

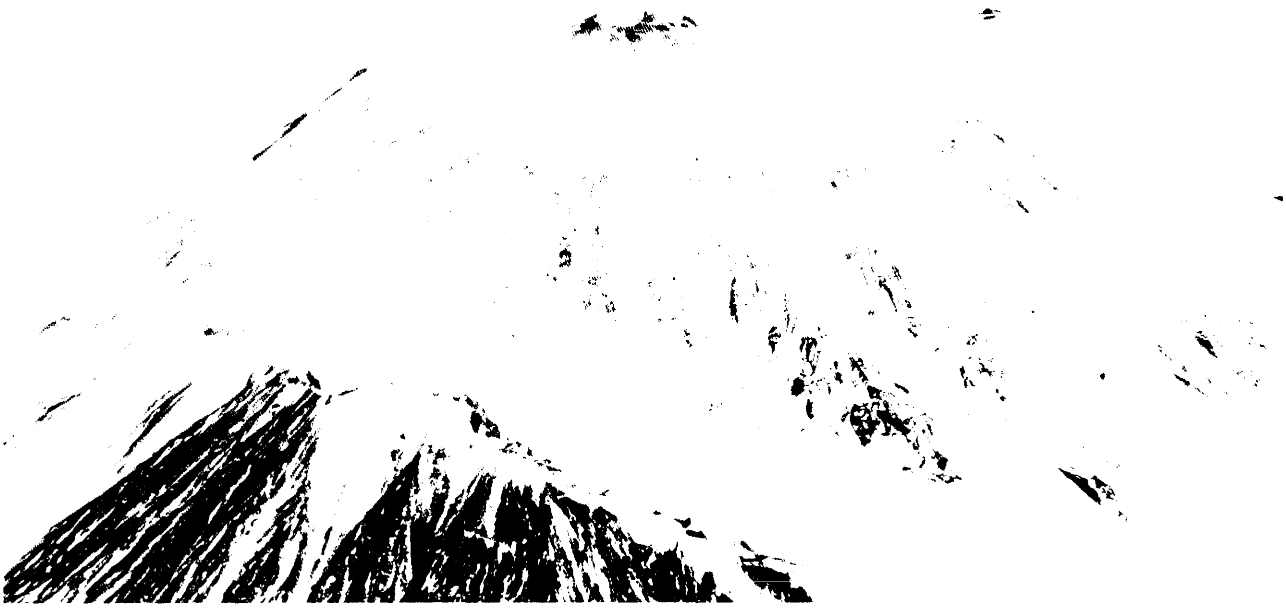


Photo credit US. Geological Survey

Mt. Erebus, the 12,447-foot volcano forming the apex of Ross Island. McMurdo Station is a tiny speck at the tip of the snow and ice-covered peninsula to the right of the volcano's summit.

tion has not entered into force, ATCPS may feel they are no longer bound by the "voluntary restraint' policy in effect since 1977.

Most of the parties involved in the Convention negotiations believe that a major discovery made in the absence of the Convention could initiate an unregulated "gold rush," which could lead to the unraveling of the entire Antarctic Treaty System. The Parties decided they needed an agreement *prior* to a major minerals discovery, because it would be harder to reach an agreement afterwards. An agreement concluded after a major discovery is made might have fewer environmental safeguards or be less balanced between nonclaimant and claimant interests.

In the absence of an agreed multilateral legal framework, exploitation might be subject only to the laws of the country sponsoring it or to conditions agreed bilaterally between a Sponsoring State and a claimant state. In either case the rules would not necessarily be designed to protect the Antarctic environment. Moreover, whatever regulations were deemed to apply may not be in the interests of the other countries that contend they also have a stake in Antarctica's resources. Friction could result if any state decided to act unilaterally or with one other, ignoring others' interests in the region. The potential for friction is especially great *in the* Antarctic Peninsula, the continent most hospitable area. The Peninsula is claimed by three states: Chile, Argentina, and the United Kingdom. The 1982 Falkland Islands war is a reminder that military conflict can occur in the region.

If the Convention is not ratified and an important mineral deposit is found, claimant states could conclude they have much to lose by compromise with others. Dormant claims could be reasserted by a claimant willing to risk good relations among fellow ATCP members for the sake of exclusive benefits from resources in ''its' area. Likewise, nonclaimants that attempt resource exploitation in a claimed area would risk the hostility of other ATCP members and of the relevant claimant(s). Even unregulated exploitation of the single unclaimed "slice" of Antarctica could potentially undermine or destroy the ATS.

The United States is a prime architect and supporter of the ATS. Consistent with this interest, it took a lead role in negotiating the Convention to strengthen the System by filling a large gap. Even though the Minerals Convention does not address all details of how minerals development shall be regulated, it is a key evolutionary step, without which the ATS would be incomplete.

Since there is potential for breakup of the ATS if a major discovery were made in the absence of the Convention, the Parties are better off with regulations than without them. An important consideration in whether the required number of ATCPs will ratify the Convention is how fairly they perceive they have been treated on the claims issue. Protection of the juridical positions of both claimant and nonclaimant countries is an essential element in this and other agreements of the ATS. The Minerals Convention does not resolve the claims issue, but skirts it like other ATS agreements. Conceivably, some nonclaimant states could reject the Convention because they believe it goes too far in recognizing special interests of claimants. Conversely, some claimant countries may consider rejecting it because ratification would mean recognition that claimants do not have exclusive mineral rights in areas they claim. To reach an agreement, ATCPs have had to compromise on issues related to claims; negotiators for both claimant and nonclaimant states appear to have recognized that doing so is in their mutual interest.

If the Convention is ratified, ATCPs may then be able to devote more attention to other pressing Antarctic issues, including the present problematic rise of tourism in the region, and-in light of the recent vessel accidents in Antarctic waters—improved vessel safety and pollution control and a general liability regime to cover pollution incidents. Even if no exploration and development occur, the Convention at least provides a clearer regime for prospecting.

Does the Agreement Advance U.S. Interests?

As mentioned, the United States has a strong interest in strengthening the ATS as a means of keeping the region peaceful. The Convention advances this interest by keeping the territorial dispute frozen and by addressing the long-standing gap in the ATS on mineral resources. The United States was key in negotiating the Antarctic Treaty in order to prevent Antarctica from becoming ''the scene or object of international discord.' The Treaty prohibits any measures of a military nature, including establishment of military bases, carrying out of military maneuvers, or testing of any weapons.[13] The Treaty also ensures that the United States benefits from its sizable past investment in Antarctica and current expensive year-round presence there. It enables freedom of access to the entire region. The United States has been a strong leader in the development of the Antarctic Treaty System. The United States can ensure that its leadership role continues through ratification of the Convention and continued participation in elaborating it.

By carefully prescribing conditions under which activities could take place, the Miner-

[13]Antarctic Treaty, Art. I.

als Convention advances the U.S. interest in preserving the Antarctic environment. In terms of environmental protection, the Convention may be one of the strongest international agreements negotiated to date.[14] If minerals exploration and/or development goes forward, there could nevertheless be serious environmental consequences. The Convention does not detail all elements of the environmental protection program. Moreover, how compliance and enforcement would work and how strong the regime would be in practice is uncertain at this stage. Nevertheless, prospecting, exploration, and development will have to meet stringent and binding environmental standards and be subject to rigorous impact assessment procedures. **While the Convention makes development possible under certain circumstances, it does not presume that any development will take place.**

The United States also has an interest in providing an opportunity for U.S. private industry to develop Antarctic resources if and when such development is feasible and appropriate. The regime established by the Convention is not intended to promote Antarctic minerals development. In fact, it contains some stringent controls on development. The hurdles that a potential developer would have to clear before proposed minerals development could proceed are demanding. **On balance, the Convention appears to be weighted more toward restricting development than assisting it.** Potential developers are concerned about environmental protection requirements and also about having to satisfy the concerns of many different countries before being allowed to proceed with a project. Like environmentalists, they worry that elements of the regime are ambiguous.[15] Some have argued that the Minerals Convention discriminates against private entrepreneurs and favors state-controlled enterprises that receive government funds, but this conclusion is difficult to prove.

Despite these concerns, U.S. private companies who have studied it generally support ratification of the Convention, if somewhat unenthusiastically. The current Convention is preferable to no agreement, they argue. U.S. companies already are used to complying with stringent regulations in the United States and abroad, so they should be able to do so in Antarctica if the potential economic gain is adequate. U.S. companies would not be interested in Antarctica's minerals resources in the absence of an established legal regime.

Achieving an appropriate and workable balance between environmental protection and resource development is difficult in any context. In the Antarctic, both must be weighed against the primary U.S. interest of strengthening the ATS and its underlying principles. **In the long run, issues of concern to both commercial and environmental interests may be secondary, so long as these underlying principles, which assure the political stability of the region, are maintained.**

Are There Different Types of Agreements That Would Be Better Than the Minerals Convention?

The most discussed alternative is banning all mineral resource activities in Antarctica, possibly by designating the entire continent as a world park or ATCP-administered wilderness reserve. Several ATCPs have indicated opposition to mining in Antarctica and stated that they would prefer a "full protection option" if the Minerals Convention is not ratified.[16] The Antarctic and Southern Ocean Coalition, which

[14] Letter from Lee Kimball, International Institute for Environment and Development—North America, to Jacques-Yves Cousteau, the Cousteau Society, Sept. 19, 1988.

[15] See, for example, the discussion about the appropriate interpretation of Art. 54, in ch. 3, p. 80.

[16] As of August 1989 two claimant countries, France and Australia, had not signed the Convention. Each has stated that it has concerns about the environmental impacts of mineral resource activities. Signature indicates an intent to ratify but is not required for ratification or accession. Six 'Australia Advocates 'Wilderness' Status for Antarctica," *Christian Science Monitor,* May 24, 1989, p. 4.

represents a number of environmental organizations, has recently urged adoption of an Antarctic Conservation Convention instead of the Minerals Convention.[17] A ban on development would eliminate controversy over minerals activities and would advance U.S. environmental interests. But unanimous support among the ATCPs for an outright ban would be difficult to achieve. Certain states, including the United States, also wish to assure access to the continent's resources, with the proviso that no significant harm should be inflicted on its environment. This option has no chance of success unless all states with policies of maintaining national access to Antarctic minerals can be persuaded to change them.

Even if some resource development is allowed, the vast majority of Antarctica, including most of the 2 percent that is ice-free, is likely to remain essentially undeveloped. In addition, the Minerals Convention effectively bans mineral resource activities absent a consensus decision to allow them in a specific area. Even then, a separate consensus decision is required to open each area considered.

Other theoretical alternatives include:

1. scrapping the present Antarctic Treaty System in favor of a regime managed by the United Nations,
2. recognizing the claims and treating Antarctica as no different from any other area under sovereign control,
3. convincing claimants to exchange their exclusive claims for a condominium in which all ATCPs would jointly own Antarctica's resources, or
4. doing nothing, hoping that the status quo would not be challenged by a major resource discovery.

For different reasons, it does not appear that an international consensus could be reached for any of these potential alternatives. Regarding the first alternative, ATCPs have strongly opposed involving the United Nations in the past and believe only those countries with demonstrated special interests in Antarctica should be fully entitled to participate in establishing and operating a regime for the continent. They also realize their own influence would be diluted in the broader U.N. forum.

On possible recognition of claims, alternative 2, neither the United States, which reserves the right to make a claim of its own, nor other nonclaimants have been willing to seriously consider changing long-held claims policies. In the case of the overlapping claims of Chile, Argentina, and the United Kingdom, which claim should be accepted? And if the United States or Soviet Union should ever decide to make claims, the situation would become even more difficult. Likewise, alternative 3, canceling claims in favor of a condominium, has always been rejected by the claimants. It also becomes more problematic as the number of ATCPs continues to increase. **In general, given the history of the claims, the multilateral nature of the negotiation, the conflicting interests at stake, and the unique juridical status of Antarctica, it is unlikely that a fundamentally different regime could have been negotiated.**

Can Provisions of the Existing Agreement Be Made More Satisfactory If We Choose Not To Ratify It in Its Present Form?

The provisions of the Minerals Convention were negotiated as a package, and compromise was the price of an agreement. The Convention cannot be amended until 10 years after it enters into force. The Convention must either be ratified or accepted as is or rejected. **The United States, with its veto, as well as each of the seven claimant states and the Soviet Union, can unilaterally prevent the Convention from entering into force.** A veto would carry no

[17] Antarctic and Southern Ocean Coalition, "Permanent Protection for Antarctica: A Conservation Convention is Urgently Needed," ASOC Information Paper No. 2, May 11, 1989.

assurance that the parties would try to negotiate a different accord. **If the Convention does enter into force, the United States or any other Commission member could prevent exploration and development later by exercising its veto at the area identification stage.**

Ratification of the Minerals Convention would advance important U.S. interests in Antarctica, including securing nondiscriminatory access to Antarctica's mineral resources and protecting the environment, as well as in maintaining the peace and strengthening the ATS. There are no compelling reasons for the United States to reject the Minerals Convention. As a member of all the regime's institutions, the United States could be influential in the continuing evolution of the Minerals Convention, as well as in protecting U.S. interests. Moreover, implementing legislation required to enable domestic agencies to carry out resource-related responsibilities in Antarctica provides an opportunity for Congress to define environmental and development interests and to clarify U.S. interpretations of ambiguous elements of the regime.

THE RESOURCE POTENTIAL OF ANTARCTICA

Although several countries are conducting geologic research in Antarctica and interest in prospecting is growing, little is currently known about its actual mineral resources. There are no known mineral deposits of commercial interest. The limited knowledge about Antarctica's mineral resources has been gained through fieldwork by geologists and geophysicists, mostly in the 2 percent of the continent that is not covered by ice or on the surrounding continental shelves. Some insight into the possible prospects for ore mineralization or petroleum accumulation in Antarctica has been gained through knowledge of the deposits that have been found on the surrounding continents in related geological environments. This has been possible because Antarctica is thought once to have been part of a larger continent called Gondwana that, before breakup, included South America, Africa, southern India, and Australia.

Photo *credit* ***U S Geo/ogca/ survey***

Aerial view of the U.S. South Pole Station.

The best prospects for petroleum exploration are the offshore sedimentary basins surrounding Antarctica. Sedimentary basins on the continent are covered by the thick ice cap, and thus, in the absence of significant technological developments, are inaccessible for exploitation. Based on what is currently known about the thickness, organic content, age, and thermal history of sediments in offshore basins, the most interesting areas are the Weddell and Ross embayments in West Antarctica, and Prydz Bay and the Wilkes Land margin in East Antarctica.

Until detailed exploration in these sedimentary basins is carried out, including extensive seismic surveys and exploratory drilling, meaningful estimates of resource potential cannot be made. Past estimates of Antarctica's oil potential have been based on virtually no data and may be very misleading.

While some Antarctic basins may ultimately attract commercial interest, the sedimentary basins in the surrounding continents that have counterparts in Antarctica are not, for the most part, major petroleum producing areas. The U.S. Geological Survey estimates that a general reconnaissance program for all of Antarctica could cost about $250 million over a 10-year period, the largest cost element being logistical Support (See ch. 4).

Scientists have discovered small amounts, termed occurrences, of many different types of metallic and nonmetallic minerals in Antarctica. However the only known substantial mineral accumulations, or deposits, in Antarctica are iron ore and coal. Low-value, high-volume deposits such as these, which are plentiful elsewhere in the world, would not be of economic interest in Antarctica. It is highly unlikely that an export market for Antarctic coal or iron ore would develop.

The Antarctic Peninsula presents the best opportunity for finding hard mineral deposits on the continent, in part because of the greater proportion of exposed rock there. Based on the geology of the Peninsula, the best prospects for discovery are base metal (copper, lead, and zinc) and precious metal (gold and silver) deposits. Outside the Antarctic Peninsula, the chances of finding mineral deposits in exposed areas are small. One exception could be the Dufek Intrusion in the northern Pensacola Mountains 300 miles from the coast, although little of it is exposed. This intrusion has a possible analog in the mineral-rich Bushveld Complex in southern Africa, and thus, could host platinum group metals, chromium, copper, cobalt, and/or nickel. Virtually all of the potentially economic minerals known to occur in Antarctica are currently abundant in other, more accessible areas of the world.

The prospects for finding placer deposits or deposits enriched by weathering are also low throughout Antarctica. The required near-surface weathering processes and significant particle transport by running water have not occurred in Antarctica since the onset of glaciation 35 to 40 million years ago. Furthermore, these types of deposits tend to be found in lowland areas rather than on mountain tops, which comprise most of the exposed rock in Antarctica.

ENVIRONMENTAL CONSIDERATIONS

The potential for minerals development in Antarctica raises concerns about the impacts that minerals activities could have on the area's terrestrial and marine ecosystems and atmosphere. The Minerals Convention includes binding general standards and procedures designed to 'ensure that any resource development that does take place occurs in an environmentally sound manner. However, the Convention does not provide detailed environmental regulations. The key to minimizing and mitigating adverse environmental impacts will be future elaboration of more detailed criteria and regulations to interpret and apply the general standards, guidelines, and procedures. United States implementing legislation may provide a measure of the environmental protection regulations and programs that eventually will be developed collectively by the Parties. In addition, much more environmental data and information will be needed before decisions about the acceptability of minerals activities can be made.

The Minerals Convention contains important compliance and enforcement provisions. However, there are important questions about how well these provisions will work in practice. Strong enforcement provisions have been difficult to agree on in the Antarctic context because they are interpreted by claimants as bearing on their rights to police their national territory. Any issues that touch on claims may not be treated as thoroughly as those in which sovereign rights are not an issue.

Local impacts from any minerals development that does take place will be unavoidable. Mere construction of facilities, for instance, not to mention land-based mining itself, will have significant but probably only very local impacts. Siting of facilities in any case may be difficult: facilities will likely be constructed on solid ground, and good facility sites are rare and potentially already occupied by wildlife or scientific bases. It is doubtful that resource activities will be allowed in environmentally sensitive areas or in areas important to science.

A major oil spill from a tanker accident, such as the recent *Exxon Valdez* accident in Alaska, or a well blowout, although rare events, would be two of the more significant unintentional impacts associated with development and would have regional as well as local impacts. In particular, such a spill in a coastal area could have substantial and long-lasting effects on large numbers of birds and/or marine mammals; a similar spill in the open ocean would be of less concern. **As illustrated by the recent oil spill by the Argentine supply and tourist vessel Bahia Paraiso, the Antarctic Treaty Consultative Parties are not now adequately prepared to contain and clean up offshore oil spills in Antarctica.** (To its credit, however, the U.S. National Science Foundation mounted its response effort quickly). Improvements in technology and response capability could—and undoubtedly will—be made prior to any Antarctic oil development; however, oil spill equipment and countermeasures for use in harsh environments are limited at present. Although it is essential to be as prepared as possible, it is unlikely that significant amounts of oil **could be** recovered from a major accident in any harsh operating environment, including Antarctica, using today's best recovery technology.

Environmental impacts from past activities in Antarctica would probably be considered by most people to be insignificant. Most impacts (e.g., disposal of wastes generated by normal human activities) have been restricted to the terrestrial and nearshore marine environments in the immediate vicinity of the 48 year-round and 19 summer research stations operated by 18 nations. Undoubtedly, the most significant past impacts have been caused in offshore areas by overharvesting fur seals, whales, and fish. However, human activity has been increasing in Antarctica and is likely to continue to grow. Future impacts can be expected to increase as well. Minerals development per se is not expected to be an immediate concern. Of more importance in the near-term will be activities related to science, tourism, harvesting of living resources, and perhaps minerals prospecting. Environmental impacts associated with geological and geophysical prospecting are likely to be insignificant and no different from those associated with similar science activities, unless done on a large scale by many countries.

Mineral resource development in Antarctica, and especially accidents resulting from exploration or development, could adversely impact some research projects and the value of Antarctica as a science laboratory. Projects dealing with biological processes or ecosystem dynamics would likely be most affected by nearby development activities or oil spills. However, most Antarctic research would probably not be adversely impacted by resource activities. Understanding of oceanography, marine ecology, meteorology, and cold-region engineering could be improved by the research needed to prepare for resource recovery.

TECHNOLOGY AND ECONOMIC CONSIDERATIONS FOR OIL DEVELOPMENT

Whether oil companies will have the technical capabilities to develop any large fields found in Antarctica depends on both the specific environmental and geological conditions where the field is located and on the status of' technology. Whether they will have the incentive to develop a field depends on profitability and risk, both political and financial. Considering eco-

nomic and political constraints, as well as the long lead times that would be required to produce oil in Antarctica, OTA does not expect that any oil production would take place in Antarctica sooner than the next 30 years, if ever.

It is unlikely that anything smaller than a world-class giant (500 million to 5 billion barrels of recoverable oil) or super-giant (over 5 billion barrels) field with high productivity will ever be economic to develop in Antarctica (see ch. 4 and app. A). Probably only a handful of such large, high-quality fields are left to be found in the entire world, so a discovery in Antarctica would be likely to attract commercial interest.

The rigorous environment of Antarctica is such that oil production there will probably be more difficult than production thus far anywhere else in the world. Most of Antarctica is colder, stormier, and more isolated than other challenging areas in which the oil industry has operated, and it has a continental shelf three to six times deeper than the global mean. Even so, **required technologies for some types of Antarctic development will probably not be substantially different from those now used, or contemplated for use, by major firms in other harsh operating areas.** Offshore technologies have evolved in discrete, incremental steps over the last 20 years, as industry has moved into ever more difficult areas. Exploration is currently underway, for instance, in the relatively shallow but seasonally ice-covered Beaufort and Chukchi Seas offshore Alaska and Canada; the iceberg-prone region between Greenland and eastern Canada; and the North Sea, North Atlantic, and Norwegian Sea. To date, the most significant production experience in harsh environments has been in the North Sea, but production in very deep water has begun in such areas as the Gulf of Mexico and offshore Brazil.

The easiest type of offshore development that **can be** contemplated-and likely the first type of development that would be tried in Antarctica—would be one in an area relatively free of icebergs. For this type of development, most of the technology is available, although a complete system would require combining technologies developed for ice-covered areas and for deep water. The industry does not yet have much experience operating in environments characterized by both deep water and seasonal sea ice and/or icebergs.

In areas where icebergs are likely to be a problem, additional technology development, some of which is underway now in other hostile areas, will be needed. Since long lead times and appropriate economic incentives will be needed in any case to bring a field into production in Antarctica, the required technology is likely to be available by the earliest credible date a project could be brought on stream. Technologies for use in other hostile areas (e.g., the iceberg-prone Labrador Sea) are likely to continue to be improved, and these would be available for use in Antarctica.

It will likely be technically possible to produce oil from under Antarctica's ice shelves and moving ice cap some day; however, new technology will be needed to develop any fields found in these areas.

OTA constructed several hypothetical scenarios (see app. A) to illustrate likely technology requirements for offshore oil development in Antarctica and to gain some insight into the economics of producing oil there. This modeling exercise, although fraught with uncertainty, indicates at least a doubling of current world oil prices would be required to develop a very large oil deposit on a commercial basis in Antarctica. OTA assumed very favorable circumstances in its scenarios: first, that a world-class giant field is discovered in an area in which production is technically feasible; second, that the timing of development is far enough in the future so that all pre-production activities can be accomplished and all needed technology is available;

and third, that the Parties determine that development in the area in which the field is located is consistent with the standards of the Minerals Convention and that they assure the developer rights to produce the field. If these assumptions are not realized, an Antarctic development prospect probably would not go forward.

OTA also examined briefly the potential for producing Antarctic oil in the context of future world liquid fuels supply and demand. Given the many uncertainties involved in projecting what may occur 30 years or more from now, definitive statements are not possible. There appear to be enough proven reserves of conventional oil on hand to satisfy world oil demand at least through 2020. Also, many alternatives to the use of conventional oil exist--ego unconventional heavy oil, tar sands, and oil shale-which given higher prices could ultimately contribute significant amounts of energy to the world supply. Conservation and the greater use of alternatives to liquid fuels may become more important as the price of oil rises. Global warming could induce countries to decrease **the** use of fossil fuels. All these factors would tend to delay or deter serious consideration of Antarctic oil. Even so, the discovery of a large oil field anywhere in the world, including Antarctica, will attract commercial interest. If such a field is found in Antarctica and could be developed at a profit, chances are high that someone will wish to do SO.

TECHNOLOGY AND ECONOMIC CONSIDERATIONS FOR HARD MINERALS DEVELOPMENT

Some insight into the technical feasibility of developing a hard minerals mine in Antarctica can be gained from the experience of mining in the High Arctic. Mining has been conducted in severe winter climates north of the Arctic Circle for more than 30 years, and technologies for both open pit and underground mining have evolved to cope with the attendant difficult operating conditions. The costs to develop Arctic mines are much higher than those for mines in more temperate climates. Thus, only world-class deposits in relatively accessible areas, like the Polaris lead-zinc mine located along the coast of Little Comwallis Island in northern Canada, have been economic to develop. Such deposits typically contain in situ ore valued at more than $200 per ton.

In general, mining operations in most of Antarctica will be even more difficult and costly than operations in the Arctic, given Antarctica's greater isolation and more severe climate. Mines would have to be located on land masses generally free of snow and ice. Transportation of fuel and concentrates would be difficult and costly tasks. Port facilities would be expensive and hard to locate, build, and maintain. However, **world-class deposits of equal or greater size and quality to those now being mined in the Arctic could probably be mined economically in the reasonably accessible parts of Antarctica, such as coastal locations on the Antarctic Peninsula.** Existing mining, processing, and transportation technology could be adapted for use in these areas. In place ore values of from $200 to $400 per ton, depending on the location, would probably be required.

The hard mineral deposits with the best prospects for economic recovery in Antarctica would be low-volume, high-value deposits such as gold, particularly if found on the Antarctic Peninsula. A reasonably accessible, high-grade gold deposit would be a relatively good economic prospect because the gold product would not be as costly to transport as bulkier ore concentrates. **The likelihood of economic exploitation of hard minerals outside the Antarctic Peninsula is low, especially in the relatively inaccessible inland areas.** Developing a mine in the interior of Antarctica would be extremely difficult, and it is unlikely that mining

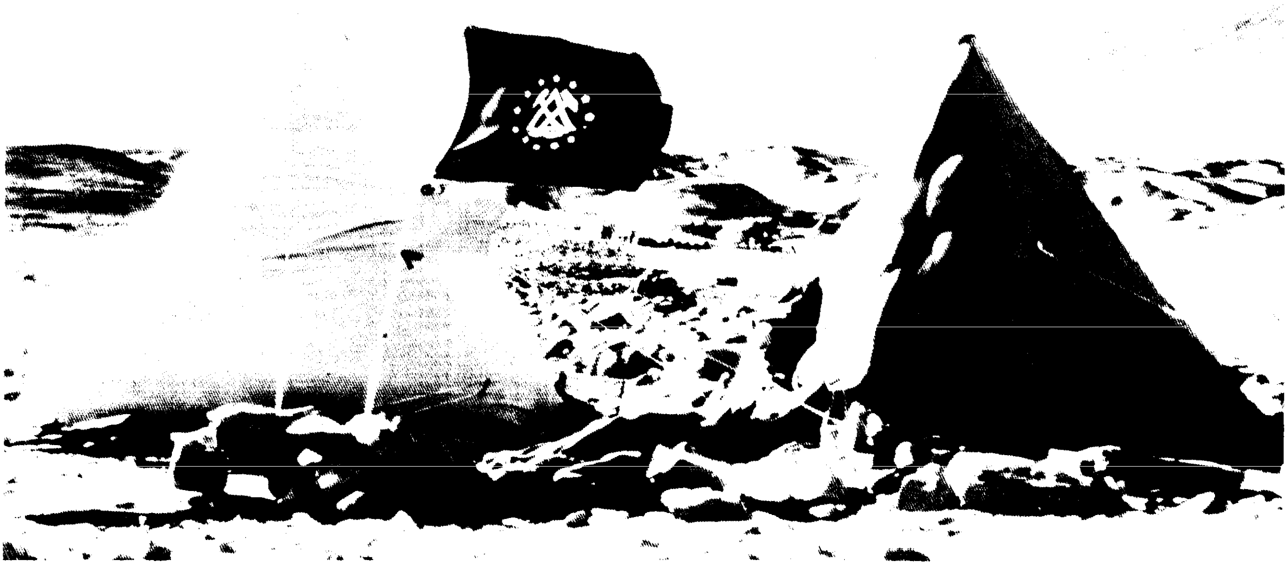


Photo credit U.S Geological Survey

USGS field camp at Lake Vanda in Dry Valley area near McMurdo.

initially would be conducted year round in harsh interior areas. The transportation system for interior operations also would be very expensive.

It is not obvious whether a hard mineral deposit or an oil field would be the first to be exploited in Antarctica if resources are discovered and exploration is allowed. Either would be of interest if it were of world-class quality. it is clear, however, that before any adequate assessment of resources can be made, much more knowledge about the geology and mineral potential of Antarctica will need to be assembled; furthermore, before any deposit could be exploited, temporal data about the operating environment will be needed, and detailed and expensive exploration of specific sites would have to be undertaken. Although one study has been optimistic about the feasibility of developing mineral resources in Antarctica's interior, OTA has concluded that this study has underestimated the costs and difficulties of Antarctic mining. [18]

[18] M. Magee, ' 'Assessment of Mining and Process Technology for Antarctic Mineral Development, " OTA Contractor report, Nov. 1988. See also D.K. Beike, "An Engineering Evaluation of Mining m Antarctica: A Case Study of Platinum,'' Master's Thesis, University of' Texas at Austin, May 1988.

IMPLEMENTATION OPTIONS

Introduction

The Senate must give its advice and consent to U.S. ratification of the Minerals Convention. If the Convention is ratified and enters into force, both Houses will have to approve implementing legislation so the Federal Government can meet at least its minimal obligations as a party to the Convention (e.g., designating representatives to the Commission, Regulatory Committee(s), etc.).

The minerals negotiations have been the driving force in the recent evolution of the Antarctic Treaty System. The United States, through the policies, programs, and institutional arrangements it chooses now, can influence the evolution of the Antarctic regime and help assure that Antarctica remains a zone of peace. Congress has an opportunity, beyond meeting minimal legal requirements, to guide U.S. Antarctic policy through the implementing legislation it adopts.

At one level, implementation requires that the broad foreign policy, political, and national security interests of the United States are fulfilled. At a second level, domestic regulatory, operational, and scientific needs related to any minerals activities the United States may choose to sponsor need to be considered. These needs would vary, depending on the scope of minerals activities the United States decides to undertake or promote. The more involved the United States becomes (or plans to become) in Antarctic resource development, the larger the required Federal effort may need to be.

This section begins with a brief discussion of the steps that should be taken in implementing legislation to ensure that the foreign policy interests of the United States are safeguarded. The primary requirement is to designate Federal agency representatives to the institutions established by the Minerals Convention.

Ratification of the Minerals Convention does not require or presume that the United States will itself become involved in minerals prospecting, exploration, or development, or even that it engage in minerals-related research. Other countries may undertake minerals activities, however, even if the United States does not; thus, the United States must have some capability to evaluate proposed activities of others. If the United States decides to sponsor prospecting itself, it must establish the added capability to evaluate and regulate Operators it may sponsor. A U.S. decision to sponsor exploration and development in the future would require an even broader capability. An important aspect of implementing legislation will be to establish a regulatory and institutional structure for managing any minerals activities the United States may sponsor in Antarctica. The second part of this section considers general regulatory needs and evaluates four possible lead agencies for Antarctic minerals affairs. A fifth alternative, creation of a United States Antarctic Agency, is considered as a future possibility if general U.S. activities in Antarctica increase significantly.

Data and information needs are likely to grow in proportion to the level of U.S. involvement in Antarctic minerals activities. These needs are discussed in the third part of this section in relation to the type and timing of minerals activities the United States could undertake.

Since a separate protocol on liability is required to be negotiated and ratified before any exploration or development in Antarctica may be allowed, the Senate may wish to consider the implications of ratifying the Minerals Convention before this protocol has been negotiated and of delaying ratification until after a protocol has been concluded. A discussion of this issue is presented in the last part of this section.

Advancing the Foreign Policy Goals of the United States

The most important justification for ratifying the Minerals Convention is to safeguard and promote the foreign policy and political objectives of the United States-that is, to protect the ATS and preserve Antarctica as a zone of peace. If the Convention is ratified, the United States can advance these objectives and maintain a continuing leadership role among the ATCPs by actively participating in it. **At a minimum then, the United States will have to decide which agency or agencies will represent it in the Convention institutions and participate in relevant policy determinations.** The United States is entitled to be represented in all institutions created by the Minerals Convention.

The interagency Antarctic Policy Group (APG) determines U.S. Antarctic policy. All U.S. representatives to the institutions of the Convention would be bound by the policies established by this group. As Chairman of the APG and lead negotiator on Antarctic policy issues, the Department of State currently represents the United States at all ATS meetings. Other Federal agencies and private sector organizations are represented on U.S. delegations to these meetings. The U.S. representative to the Minerals Convention Commission and to the Special Meeting of Parties must have the authority to represent the broad spectrum of specific U.S. interests in Antarctica. Hence, the Department of State is the most appropriate candidate to represent the United States at meetings of these institutions; other U.S. agencies could be included in the delegation as appropriate. Because the Department of State represents the United States at other ATS meetings, it is also the Federal agency best qualified to coordinate responsibilities under the Minerals Convention with other ATS responsibilities.

The Convention establishes an Advisory Committee responsible for providing advice to the other institutions on the full range of scientific, environmental, and technical issues. Each Party's representative must have suitable scientific, technical, or environmental competence or be accompanied by experts and advisors. Either the State Department, as overall coordinator of U.S. Antarctic policy, or a technically qualified U.S. expert could represent the United States on the Advisory Committee. In any case, it will be essential to draw on the expertise available in the National Science Foundation, the Department of the Interior, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the Marine Mammal Commission, the academic community, and industry. Wide-ranging exper-

Photo credif U S Geological Survey

All directions point north from the South Pole. The geodesic dome at the U.S. South Pole Station is in the background.

tise will also be required to make the decisions assigned to the Regulatory Committees, if and when they are established.

Establishing a Regulatory and Institutional Structure

At the present time, little or no interest exists in resource development per se, but several nations appear to be interested in prospecting. A major policy issue for the United States is to decide whether to sponsor prospecting. Even if it does not become a sponsor, other countries are likely to do so. Thus, if the United States wishes to be actively and responsibly involved in the institutions of the Minerals Convention and, specifically, in ensuring that others comply with the Convention's environmental and other provisions, it will need to establish some capability for evaluating the prospecting (and potentially also the exploration and development) activities of Operators sponsored by other countries.

If the United States decides to sponsor prospecting itself, a basic obligation would be to ensure that the Operators it sponsors act in a manner consistent with the principles of the Minerals Convention. In this case, implementing legislation would need to address how to regulate the Operators it sponsors, what information is required to make informed judgments about prospecting (and how to obtain it), and which agency or agencies will be in charge of any program established to carry out these activities.

The agency assigned to handle sponsorship of prospecting would need to have the capability to guide preparation of the prospecting notification to the Commission, to evaluate and possibly prepare environmental impact assessments, and to monitor the activities of Operators. Implementing legislation might include procedures and information requirements for sponsoring, evaluating, and certifying U.S. Operators seeking to undertake Antarctic mineral resource activities; procedures for meeting environmental impact assessment requirements; procedures and criteria for determining that an operator has and maintains the necessary substantial and genuine link with the United States; procedures and criteria for determining the financial and technical qualifications of operators; procedures and criteria for suspending or terminating sponsorship; provisions to make violations of the Convention violations of U.S. law; and provisions establishing at least an interim liability regime for prospecting pending entry into force of the liability protocol.

Initially, there may actually be little that a Federal entity responsible for prospecting would be required to do. The data and information requirements to demonstrate consistency with Minerals Convention standards will be relatively small compared to what would be required for exploration and development, and the impacts associated with prospecting are expected to be negligible. In addition, the amount of activity likely to take place in the near term is not likely to be great. Hence, new responsibilities could probably be accomplished by a small staff. A similarly small program would be indicated if the United States decides not to sponsor prospecting itself **but** only to establish the capability to evaluate and monitor Operators from other countries. In designing a program and assigning responsibility for evaluating and overseeing prospecting, Congress and the Administration may want to keep in mind that the same entity may be called on later to consider and regulate exploration and development.

Currently, no existing agency has the full range of experience and capabilities to implement a prospecting program (and potentially an exploration and development program as well). Beyond its major role in coordinating and advancing U.S. Antarctic policy, the Department of State is not equipped to play a major role in regulating minerals activities. It does not have the experience, the mandate, or the technical expertise to evaluate and regulate operators or to manage any directed research. Indeed, **only three executive agencies approximate the**

legislative mandate and experience required to meet the major demands of the Minerals Convention: the National Science Foundation, the Department of the Interior, and the National Oceanic and Atmospheric Administration in the Department of Commerce.

The National Science Foundation (NSF)

The National Science Foundation has been active in Antarctica since 1957 and responsible for U.S. research activities there since 1971. The Foundation's United States Antarctic Program is responsible for research, operations, and logistics. The Program's budget requests are made and defended by NSF. Unless there is a major change in U.S. Antarctic policy, NSF will continue to play a major role on the continent.

There are four reasons why NSF might be chosen to administer a mineral resource program. First, the Foundation's support for Antarctic research has provided a sound basis for addressing the environmental and resource information needs required if prospecting, exploration, and development are undertaken. Second, any effort in Antarctica must depend on reliable logistics, experience, and capability. The National Science Foundation, in close cooperation with the U.S. Navy, has developed the necessary skills and has the specialized equipment required for working in the continent's hostile environment. It could provide useful advice to commercial operators in Antarctica. Third, NSF has established strong ties to the relatively small community of academic researchers and program managers whose expertise will be critical for addressing the resource and environmental assessment issues central to the Convention. Finally, successive administrations have charged the Foundation with responsibility for a wide range of U.S. Antarctic activities; thus, NSF has an established legitimacy domestically and internationally.

There are, however, limits to an expanded NSF role. The National Science Foundation's overall mandate is to be the primary Federal patron for basic academic research. One consequence has been a deep reluctance to support in any sustained fashion the environmental monitoring, survey, or baseline activities anticipated by the Minerals Convention and typically performed by mission-oriented agencies, and a similar reluctance to support directed research aimed at determining the resource potential of Antarctica.[19] Although NSF has been responsive to proposals generated by academic scientists, it has not assumed leadership for development of the kinds of resource assessment programs of increasing interest to other government agencies, environmentalists, or commercial interests. For example, the Foundation did not play a prominent role in the negotiation of the marine living resources treaty (CCAMLR) or the Minerals Convention. Even with additional funds, NSF's academic constituency would be reserved in its enthusiasm for such an expanded role, particularly since it could mean that funds for basic research would be diverted to support the applied work needed to support U.S. minerals activities. However, NSF could acquire the capability to undertake long-term monitoring in Antarctica if directed to do so.

More generally, NSF has expressed little interest in developing long-range policies for the U.S. Antarctic Program outside the continued support for basic research and logistics. For example, it does not support a separate policy and planning staff that addresses issues such as tourism and resource development except as

[19] The potential for conflict with mission agencies was suggested by the U.S. Geological Survey, which argued that t-he "directed short-term research" called for in President Reagan's 1982 policy statement did not meet long-term needs in earth sciences. Furthermore, the charge to NSF to support university and Federal agency research in Antarctica put federal agencies m competition with academic institutions for funds, rather than establishing funding opportunities that would nurture complementary agency and university programs. *The Role of the National* Science *Foundation in Polar Regions*—A Report to the National Science Board (NSB-87-128), p. 8.

they affect NSF's basic science mission.[20] Moreover, the Foundation has no natural resource management experience or responsibilities. To assign NSF the responsibility for implementing the Minerals Convention would require additional staff experienced in the administrative, procedural, technical, and economic dimensions of resource management, and would mark a significant departure from the Foundation's traditional basic research mission.

The National Oceanic and Atmospheric Administration (NOAA)

The National Oceanic and Atmospheric Administration includes among its missions responsibility for directed and applied research to support marine resource management. Its areas of direct responsibility include fisheries, marine mammals (in conjunction with the Fish and Wildlife Service), marine and estuarine pollution, and the implementation of the 1980 Deep Seabed Hard Mineral Resources Act, including assessment of the environmental impacts of deep seabed minerals development. The National Oceanic and Atmospheric Administration is generally perceived as more responsive than other resource management agencies to the concerns of environmental interests, and has also received the support of the deep ocean mining industry for its responsiveness to the special requirements of that industry.

Although NOAA's field experience in Antarctica is limited relative to NSF's, NOAA scientists have conducted research in the Southern Ocean. The y have also conducted research in the Arctic in support of the U.S. Alaskan Outer Continental Shelf leasing program.[21] The National Oceanic and Atmospheric Administration also has extensive environmental data archiving capabilities. For example, the National Environmental Satellite Data and Information Service compiles and maintains a variety of Antarctic data sets. In response to the requirements of the Antarctic Marine Living Resources Convention Act of 1984 (Public Law 98-623), NOAA has been given responsibility for directed research on the living marine resources of Antarctica. The information generated by this program will be essential for environmental impact assessments of proposed oil and gas activities on the Antarctic continental margin.

The National Oceanic and Atmospheric Administration also has research and management responsibilities for deep seabed hard minerals. The Deep Seabed Hard Minerals Resources Act of 1980 (Public Law 96-283) mandated that NOAA establish procedures for the orderly exploration and commercial recovery of manganese nodules from the deep seafloor. The act is relevant to the Antarctic Minerals Convention because it provides a regulatory framework for the management of mineral resources beyond the limits of U.S. jurisdiction. The absence of territorial control required that the United States base its jurisdictional claims on the power of the United States to regulate activities of its citizens outside its territory.

The National Oceanic and Atmospheric Administration grants licenses for exploration and permits for commercial recovery for areas of the deep seabed selected by an applicant who must prove financial and technological capability to conduct the proposed work. The agency is also required to prepare an environmental impact

[20] A comprehensive review of NSF's role in polar regions indirectly acknowledged that the Foundation had not played a prominent role in policy issues when it recommended that it become more active in policy analysis and decision-making on Arctic and Antarctic policy issues through evaluation of potential policy issues and options. *The Role of the National Science Foundation in Polar Regions*, ibid., p. 52.

[21] Without pressing similarities too far, the experience in the arctic is instructive. Prior to 1973, there was little information available with which to assess the impact of oil and gas development, particularly along the Alaskan margin. Because the Department of Interior's Bureau of Land Management (BLM) lacked the inhouse capabilities to work on the Alaskan shelf, it contracted with NOAA in 1974 to design and manage an environmental studies program, the Outer Continental Shelf Environmental Assessment Program (OCSEAP) for Alaskan Studies. The program has since become one of the most comprehensive programs of its kind for the collation and assessment of arctic environmental information. NOAA contracted with the U.S. Geological Survey for much of the geology and geophysical work conducted. *Oil and Gas Technologies for the Arctic and Deepwater.* (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-0-270, May 1985), p. 165.

statement before granting a license or permit, both of which are contingent on steps to protect environmental quality and to conserve the mineral resource. Although commercial deep ocean mining has yet to occur, NOAA has established a framework to accommodate these activities once they become economically attractive. The National Oceanic and Atmospheric Administration also has a fleet of vessels capable of conducting and supporting research in Antarctica.

However, NOAA has much less experience in Antarctica than NSF. Moreover, it has had no legal mandate, research experience, or management responsibility for onshore minerals.[22] While NOAA has developed a scheme to manage deep ocean mining, it has so far no experience in managing development of these resources. More generally, assignment of sole responsibility to NOAA for both scientific and minerals management responsibilities could undermine NOAA's identity in the environmental community as a resource conservation agency.

The Department of the Interior

Interior has a clear legislative responsibility as well as broad experience on a wide range of mineral and environmental resources in the United States and U.S. Exclusive Economic Zone (EEZ). Interior's activities are pursued through several agencies in the department, in particular, the Minerals Management Service (MMS), the Bureau of Land Management (BLM), the U.S. Geological Survey (USGS), and the Bureau of Mines (BOM).

Minerals Management Service-MMS is responsible for offshore minerals leasing and lease management under provisions of the Outer Continental Shelf Lands Act. The Minerals Management Service has programs to:

- manage the leasing of oil and gas and other minerals in offshore areas under the jurisdiction of the United States (including U.S. Arctic areas),
- supervise mineral exploration, development, production, and operations in accord with permits and leases issued by the department,
- collect and distribute revenue due the Federal Government from onshore and offshore mineral leases, and
- assess environmental impacts associated with minerals development in offshore areas subject to U.S. jurisdiction.

In 1973, Interior initiated the Environmental Studies Program to gather information for accelerated leasing on the U.S. outer continental shelf (OCS). First located in BLM, and then moved to the MMS when it was established in 1982, the program generates environmental information used by the Secretary of the Interior and by the environmental assessment and leasing management divisions of MMS to meet their responsibilities under the National Environmental Policy Act and the OCS Lands Act. Most of the work of this program is contracted to university researchers.

Bureau of Land Management—The Bureau is responsible for conducting programs for the conservation, development and management of both surface and mineral resources on the nation's public lands (including U.S. Arctic areas). The Bureau's main task is to manage these holdings and their resources from a multiple use perspective by seeking the best mix of uses that an area can sustain to provide the greatest public benefit. Specific energy and mineral programs include resource evaluation, leasing, and supervision of Federal and Indian coal, oil and gas, geothermal resources, oil shale, tar sands, and nonenergy minerals. In addition, BLM prepares environmental impact assessments of proposed minerals development, implements measures to mitigate negative envi-

= the other hand, Antarctica's onshore minerals are not, according to the U.S. view, within our national jurisdiction, and in this sense they are similar to deep seabed minerals. NOAA argues that it should be in charge of all resources beyond national jurisdiction, whether on land or at *sea* ronmental effects, and administers laws governing mining on public lands and the sale of minerals.

U.S. Geological Survey-The Survey is charged with enlarging the Nation's knowledge about the extent, distribution, and character of water and other natural resources, and the geological processes, structures, and hazards that affect the development and use of the land. It pursues this mandate through a program of mapping, geological research, and mineral and energy resource assessments on land and in the EEZ. Specifically, USGS researchers produce geophysical, geological, and geochemical maps and analyses which show the distribution, age, composition, structure, and physical properties of the rocks and mineral deposits at and beneath the Earth's surface. It also provides information on geologic hazards such as earthquakes, volcanoes, landslides, and land subsidence that affect human safety, urban development, and engineering design of sensitive structures. More generally, USGS provides data and analysis for use by other Federal and State agencies in the management of public lands, wilderness studies, and multiple use planning, and in national policy determinations including energy development and mineral resource availability. Several USGS scientists have experience doing geological and geophysical research in Antarctica.

Under the National Mineral Resources Assessment Program (NAMRAP), USGS has conducted systematic regional assessments of mineral resource potential in the United States. The assessments have been used for land use decisions as well as by private industry exploring for specific deposits. Based on NAMRAP experience and related geological studies and subject to congressional appropriations, the Survey could conduct a two-part program for Antarctica if the Convention enters into force: first, a regional resource assessment of the entire continent; and second, a more detailed study of areas that could have deposits of economic value.

Bureau of Mines—The Bureau of Mines is the principal Federal agency responsible for conducting research on mineral reserves and the production, consumption, and recycling of mineral materials. The Bureau's mission is to help assure that the United States has the mineral supplies necessary to maintain national security and economic growth at low social and environmental costs. The Bureau also fosters and encourages minerals production by the private sector so that national needs can be supplied by domestic sources.

If emphasis is to be on the management aspects of Antarctic minerals prospecting, exploration, and development, then assigning a major role to Interior would be a reasonable choice, given the experience of the domestic oil, gas, and minerals industry with the procedures and regulatory requirements of the various Interior agencies. Such an orientation would also be compatible with the historical emphasis on resource development in the Department of the Interior. Together, USGS, MMS, BLM, and BOM have the experience and expertise to conduct exploratory studies, establish realistic terms and conditions for minerals activities in both onshore and offshore areas of Antarctica, and to establish the regulatory requirements associated with these efforts.

Despite this experience with environmental and resource assessment, Interior has had little experience managing resource activities outside the continental United States. Were it to be assigned major responsibility for Antarctic mineral affairs, it would need to choose a lead agency within Interior. Otherwise. responsibility and visibility for Antarctic affairs would be diffuse and fragmented.

A New, Independent Commission—Rather than assigning regulatory responsibility to an existing Federal agency, a new institution could be created, such as a small commission. It could resemble the Marine Mammal Commission,[23] for instance. An Antarctic Minerals Commission could be given responsibility to monitor interest and trends in Antarctic minerals activities, initially tracking and evaluating proposals of other countries. The new agency could be designed to grow and take on additional responsibilities as the need arises. If the United States decides to sponsor prospecting, for instance, the commission could become the focal point for evaluating and regulating U.S. operators. With an appropriate budget, environmental and resource information needs could be contracted to the appropriate Federal agencies and/or to universities or private contractors.

One advantage of a new institution is that turf battles among present agency responsibilities could be set aside. It could also coordinate the activities of several interested Federal agencies. A disadvantage could be its likely low visibility; it also may have little to do in the near term. Without the protection of a cabinet department, it could be vulnerable to budget cuts. Also, because it would be small, it would succeed or fail on the strength or weakness of only a few individuals.

Additional Considerations Should the United States Decide to Sponsor Exploration and Development— Most experts would agree that there is no urgency to develop details of the larger Federal effort that would be required if at some future date the United States decides to sponsor exploration and development. These activities are unlikely to attract interest for *at least* several decades. If the United States eventually decides to sponsor exploration and development, the institutional structure we may establish to oversee prospecting could be expanded to handle the additional responsibilities that sponsorship of exploration and development would entail. Any of the four agencies discussed could be assigned added responsibilities. On the other hand, U.S. involvement in development activities would signal a much higher level of U.S. activity of all kinds in Antarctica than exists today or is likely in the near future. When the level of U.S. activity does increase significantly, however, it may be useful to meld all or most U.S. Antarctic activities into one organization. The United Kingdom and the Soviet Union have already done so.

Creating a U.S. Antarctic Agency (USAA), an independent agency with responsibility for the full range of U.S. interests on the continent, would be a major departure in the management of Antarctic policy. The essential features of such an agency would be its independent status and comprehensive responsibility for planning, implementing, and managing *all* U.S. activities in Antarctica, including logistics. Establishment of such an agency would be premised on the assumption that U.S. activities in Antarctica will increase in the future; that realization of U.S. security, environmental, economic, and scientific interests will require increased involvement in these activities; and that present Federal institutional arrangements are ill-prepared to respond to these needs.

The United States Antarctic Agency could be charged with responsibility for resource and environmental assessments and management, for support of scientific research, and for maintaining the infrastructure required to continue the national presence in Antarctica, including logistics. Technical responsibilities could be funded by the USAA but performed by other agencies. For example, NSF could continue to fund basic research projects without being encumbered by pressure to conduct directed research or to provide and manage logistics. The National Oceanic and Atmospheric Administration could continue to conduct assessments and research on marine living resources. The Geological Survey could conduct studies on geological resources and natural hazards. Although some funding might come from agency budgets,

[23]The Marine Mammal Commission is a small, independent executive branch agency with responsibility for developing, reviewing, and making recommendations on actions and policies for all Federal agencies with respect to marine mammal protection and conservation,

most could be allocated to the USAA and directed according to a long-range plan to whichever agency was most appropriate to carry out a specific task.

Such an agency would provide a clear political, administrative, and managerial focus for Antarctic affairs in the United States and meet the need for greater coordination among agencies with Antarctic responsibilities. Because it would be charged with comprehensive responsibilities, it would be in a good position to contend with the interrelationship of issues. Accountability for U.S. Antarctic policy would be clearly defined, both for political oversight and international collaboration. The Agency could have the ability to integrate plans, priorities, and national interests with budgets, and hence be in a strong position to pursue the full range of U.S. interests within funding constraints.

Efforts to establish an independent agency for Antarctica could be challenged on several grounds. First, there is an innate resistance to increasing the number of government agencies. A number of simpler institutional alternatives for implementing Antarctic policy already exist. Second, creation of an independent agency would elevate Antarctic affairs to a level of visibility that is arguably not warranted at this time. The issue-by-issue approach which has characterized U.S. involvement over the past decade has seemed to provide an adequate response to realizing international obligations and national interests on the continent. Third, the APG now plays a significant interagency coordinating role and may resist creation of a new agency that would diminish its authority. Fourth, development of a comprehensive, coordinated Antarctic program, implicit in the creation of an independent agency, implies a much higher level of funding than may be acceptable politically at present. Finally, a new institution may threaten the resources devoted to basic research in Antarctica.

Data and Information Needs

The United States is not obligated to undertake any basic or directed research as a consequence of ratifying the Minerals Convention. Data and information requirements at the prospecting stage will be relatively minor, but requirements for exploration and especially for development—if they occur—will be substantial. Available information about the Antarctic environment is not now sufficient for making informed decisions about opening parts of Antarctica for exploration and development (or for regulating activities in areas once they are opened).

Two categories of information will be especially important:

- baseline environmental information with which to assess the significance of changes in the ecosystem likely to result from minerals activities, and
- information about the basic geological, geophysical, and geochemical characteristics of Antarctica.

To date, there has been virtually no effort to plan or to support the long-term commitment of funds for long-term environmental monitoring.[24] As for geological survey and assessment, an important implementation issue is the extent to which the government will contribute to resource assessments to assist domestic minerals companies in identifying those areas worthy of more detailed evaluation and possibly development.

A program to acquire data and information should be tailored to the level of resource activity anticipated. A first step in meeting information needs could be to compile relevant databases and information on research programs and agency plans and then identify priority research needs, logistics requirements, and funding estimates. As for directed environmental

24 An exception has been the CCAMLR Ecosystem Monitoring Program, realized in the United States through the U.S Antarctic Marine Living Resources Program administered by NOAA.

research, the United States might wish, at a minimum, to begin compiling environmental baseline data. Such data would be essential for evaluating potential impacts if the United States decides to become involved in mineral resource activities and/or to evaluate the impacts of plans of other countries that may decide to sponsor activities. The United States does have a small program to gather some oceanographic data pursuant to its responsibilities under the Convention on the Conservation of Antarctic Marine Living Resources, even though it does not now fish in Antarctic waters and is unlikely to do so in the near future.

As far as decisionmaking in the institutions of the Minerals Convention is concerned, there would be little need for the results of minerals-related research in Antarctica until an area is under consideration to be opened for exploration and development. Considering the current low level of industry interest in Antarctica and the high probability that Antarctic resource development is three or more decades away, **there does not appear to be a compelling need at this time for a major Federal effort to assess Antarctica's resources A modest reconnaissance program may be justified if the United States wishes to promote long-term U.S. commercial interests in Antarctica and/or to acquire additional influence in institution meetings.** Some U.S. researchers want to establish a more aggressive minerals assessment program. Several countries have acquired more offshore geophysical data than the United States, so a U.S. program could help the United States remain competitive with other interested countries. Specific requirements for reconnaissance data are discussed in chapter 4. In general, industry presumably will be responsible for assessing resource potential beyond basic reconnaissance and for obtaining information needed for environmental impact assessments for specific areas.

The lead agency designated for managing Antarctic minerals activities will most likely be assigned responsibility for defining data and information needs even if other agencies, academic institutions, and/or the private sector are contracted to carry out some of the work. The agency designated to handle data and information might initially be assigned the relatively simple responsibility for verifying information provided by applicants (including non-U.S. applicants) for prospecting, and, ultimately, for exploration and development. It could also be given responsibility for obtaining information needed to predict and detect impacts. If desired, broader authority could be assigned the agency to assess resource potential as well. Alternatively, responsibility for acquiring environmental and resource data could be delegated to several agencies. Capabilities for acquiring and evaluating environmental and resource information could be an important consideration when designating a lead agency. As noted, no single agency currently has all the capabilities required.

A model for a directed research program is the plan implementing CCAMLR. After ratifying CCAMLR in 1982, the United States established the Antarctic Marine Living Resources Program to provide information for conservation and management of marine living resources in the oceans surrounding Antarctica. The National Science Foundation was directed to continue supporting basic research of Antarctic marine ecosystems while NOAA was directed to design an applied research program to provide information needed to detect, monitor, and predict the effects of fishing and associated activities on target, dependent, and related species and populations. The National Oceanic and Atmospheric Administration's plan describes priority research needs for the implementation of the Convention, identifies which of those needs are to be fulfilled by the United States, and specifies the design of the directed research and funds, personnel, and facilities required for the research.

An important consideration in designing a research program will be its cost. Conceivably, NSF could be directed to allocate more of its existing basic research budget to minerals-related activities. However, funding for minerals research within a fixed budget could only be accomplished at the expense of other research. Currently, applied research does not appear more important or timely than basic research that may have to be sacrificed. Given the present slight interest in minerals development, modest funding for data acquisition seems acceptable. If interest increases, a larger effort would be justified.

Cooperative projects among the Parties to the Minerals Convention would help reduce the high costs of basic and applied research. United States' backing of joint research would further its longstanding goal of international cooperation in Antarctica. Joint research also would avoid unnecessary duplication and assure all participants equal access to data. The National Science Foundation's Deep Sea Drilling Program and its successor, the Ocean Drilling Program, should be considered as models. As for prospecting, under certain conditions (e.g., when efforts would otherwise be duplicated) "group shoots" could be considered, in which companies pool their resources to conduct initial seismic exploration in frontier areas. Finally, ATCPs should be encouraged to make their seismic and other scientific data freely available as intended under the terms of the Antarctic Treaty. Countries which have not been as diligent as the United States in releasing seismic data should be encouraged to do so.

The *Liability Protocol*

Liability issues are covered in Article 8 of the Minerals Convention. However, the Convention does not treat liability issues in detail. The Parties agreed that before any minerals exploration and development can occur, a protocol specifying the details of a system of liability for environmental damage related to minerals activities must be negotiated and ratified in the same manner as the Minerals Convention.[25] It may include limits on liability, how unmet liability will be satisfied, and what means to use to assess and adjudicate liability claims.[26]

If the Minerals Convention is ratified before the liability protocol is ratified, prospecting (but not exploration and development) may begin, subject to the general provisions of Article 8 and other specified interim measures. During this period, Parties are to ensure that recourse will be available in their national courts for adjudicating liability claims, including possible claims by the Commission itself, against any Operator(s) they may sponsor. However, domestic legislation and/or agency regulations will have to interpret the Article 8 guidelines for prospecting; the liability regime for prospecting cannot be articulated solely through judicial proceedings.

The specific provisions of the liability protocol—and, in particular, those relating to limits on liability--could have an important impact on future minerals activities in Antarctica. **Should the United States Senate give its advice and consent to ratification of the Minerals Convention before the liability protocol is negotiated or wait until after it has been negotiated?**

Several arguments favor ratification of the Convention prior to negotiating and/or ratifying the liability protocol:

- Even without additional liability measures, ratification of the Convention would strengthen the ATS.
- Exploration and development may not proceed under any circumstances until the liability protocol has been ratified. Interim liability measures need only be considered for prospecting, and impacts associated

[25] See ch. 3, p, 86, for details.

[26] Negotiations for the Liability Protocol have not commenced as of September 1989, but could begin before the end of the year.

with prospecting are not expected to be significantly different from those associated with similar research activities already taking place.

- It may take several years to negotiate and ratify the liability protocol. In the meantime, a resource discovery could be made---a situation the Parties would like to avoid in the absence of a regulatory framework.
- The representatives from the countries that negotiated the Minerals Convention are, for the most part, still active and involved in Antarctic affairs. They constitute an institutional memory of how and why the minerals regime was negotiated. In several years these participants may be doing other things. Unless the Convention is ratified in the next few years, this institutional memory may be lost, and with it, the best opportunity for ratifying the Convention.
- The United States could set an early standard for effective implementation of the Minerals Convention. A domestic liability regime included as part of implementing legislation could be used to strengthen the U.S. position in negotiating the protocol as long as it did not unduly tie its delegation's hands. Thus, Congress and the Executive Branch would be the arbiters of the competing interests asserted by domestic industry and environmental groups on the liability question.

Two arguments favor waiting to ratify the Minerals Convention until the liability protocol has been negotiated.

- The remaining unnegotiated aspects of liability are potentially important. For instance, what will be the requirements for a backup source of liability if an Operator cannot pay or if limits on liability are exceeded?
- The U.S. may have more leverage over the content of the liability protocol if it makes ratification of the Minerals Convention contingent on negotiating satisfactory terms for the protocol. This strategy is available to other countries as well, however, and, if many countries pursue it, may be counterproductive. Special interest groups, in particular, may favor negotiating the protocol before ratifying the Convention: industry is concerned about the protocol because it fears the limits on liability may be set too high, thereby making economic operations much more costly, if not impossible. Some environmental groups, correspondingly, fear that limits to liability may be set too low.

Chapter 2

U.S. Involvement in Antarctica and the Origin of the Minerals Convention

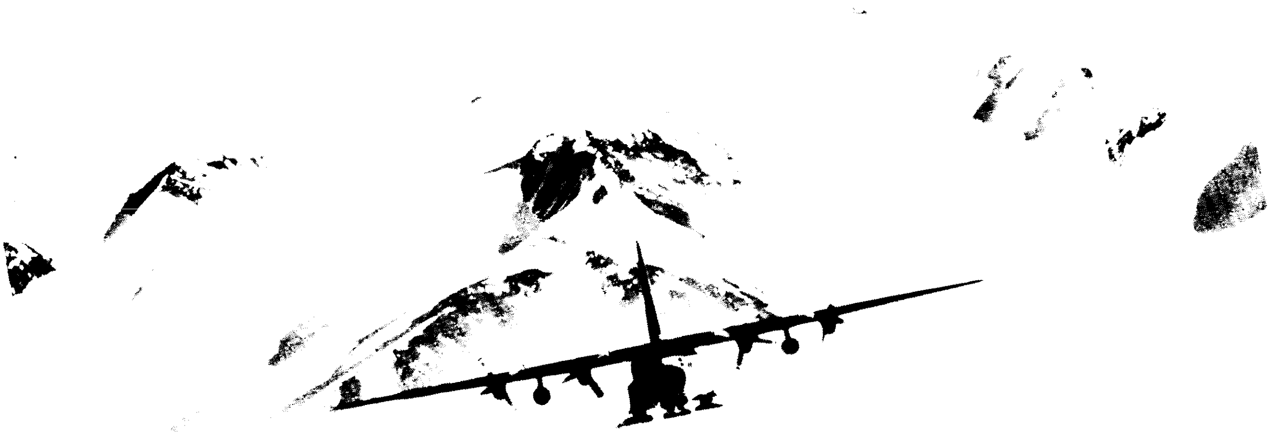


Photo credit: Ann Hawthorne

LC-130 at Beardmore South Camp

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U.S. Involvement in Antarctica and the Origin of the Minerals Convention

SUMMARY

The United States has a long history as a leader in Antarctic exploration and research. It has also influenced the development of the Antarctic Treaty System, The 1959 Antarctic Treaty is largely a product of U.S. efforts.

U.S. interests in Antarctica can be grouped into four categories: geopolitical and strategic, environmental, scientific, and economic. The paramount geopolitical and strategic interest of the United States is to maintain Antarctica as an area of peace and cooperation. Environmental and scientific interests are driven by the desire to preserve the unique ecological systems of the continent, study the relationship of Antarctica to the global environment, and use Antarctica as a laboratory for the study of natural processes. Economic interests are future oriented. It is uncertain whether hydrocarbons or other minerals, if discovered, would be economically recoverable. However, the United States shares with other consumers and importers of hydrocarbons and minerals an interest in assuring nondiscriminatory access to Antarctic resources.

The vehicle through which the United States has pursued these interests is the Antarctic Treaty System (ATS). The Antarctic Treaty System includes the Antarctic Treaty, recommendations adopted by consensus at consultative meetings, and separate conventions adopted at special consultative meetings. The ATS establishes a framework within which those nations making claims to parts of Antarctica and those, such as the United States, which neither recognize such claims nor assert ones of their own, can cooperate without prejudice to their legal positions. The ATS serves U.S. interests in stability, free access to all of Antarctica, participation in regulation of Antarctic activities for environmental and other purposes, and avoidance of conflict with the Soviet Union or others.

The Antarctic Treaty Consultative Parties (ATCPs) formally decided in 1981 to negotiate an agreement governing exploitation of Antarctic minerals. Several reasons contributed to this decision:

First, the Antarctic Treaty itself is silent about mineral resource activities since, in 1959, there was no pressing need to address them and the negotiators understood the practical difficulty of achieving a more comprehensive agreement,

Second, by enabling scientists unhindered access to ail parts of the continent, what was virtually *terra incognita* in 1959 was better known by the early 1980s, Occurrences of many minerals have been identified in Antarctica that, if found in large enough and rich enough deposits in relatively ice-free areas, would attract commercial interest.

Third, technology to exploit resources has improved significantly since the Antarctic Treaty was negotiated. Oil companies are venturing into offshore areas in the Arctic and mining companies. are operating in high latitude areas of Alaska, Canada, Sweden, and the Soviet Union. While some new technology will still have to be developed, technology is no longer a decisive limiting factor in Antarctic development.

Fourth, as early as 1969 commercial enterprises expressed some interest in prospecting in Antarctica. The Antarctic Treaty Consultative Parties realized that permitting such activities without an agreed regulatory system could upset the stability of the Antarctic Treaty.

Fifth, ATCPs perceived that they would be much more likely to reach an agreement before any major discoveries were made. The maintenance of political stability must therefore be viewed as a primary, although not exclusive, reason for negotiation of the Minerals Convention.

A factor which spurred ATCPs to complete negotiations that were already underway was the increasing interest of the United Nations in Antarctica. ATCPs have long held that by virtue of the existence of claims and bases for claims and of a long history of successful administration of Antarctica, they possess special rights and responsibilities there. They have resisted any attempts to consider Antarctic issues in the United Nations.

The cornerstone of the ATS, the Antarctic Treaty, runs indefinitely. However, any of the Consultative Parties may call for a conference to review operation of the Treaty once 30 years after its entry into force have elapsed, i.e., beginning in 1991. This date is probably not as significant as some have suggested, but perceptions are important. Having a minerals regime in place before 1991 would be strong evidence that the ATCPs are capable of dealing with problems as they arise.

INTRODUCTION

Although negotiated as a separate treaty, the Convention on the Regulation of Antarctic Mineral Resource Activities does not stand alone. It is the most recent of a series of agreements concerning conduct of activities in Antarctica. To understand why the Convention was negotiated and why it took the form it did-and, therefore, the consequences of accepting or rejecting the Minerals Convention—it is necessary to know something about creation of the Antarctic Treaty in 1959 and of the evolution of the Antarctic Treaty System (ATS).

The United States has played a major role in development of both the ATS and the Minerals Convention. This chapter examines the history of U.S. involvement in Antarctica and summarizes U.S. Antarctic interests. It also reviews the Antarctic Treaty and elements of the Treaty System, Finally, it discusses why the Minerals Convention was negotiated and the relationship between the Antarctic Treaty signatories and the United Nations. Chapter 3 describes and evaluates provisions of the Minerals Convention.

HISTORY OF U.S. INVOLVEMENT IN ANTARCTICA

There is evidence that an American sealer, Captain Nathaniel B. Palmer of Stonington, CT, may have been the first to sight the continent of Antarctica in November 1820, although both Great Britain and the Soviet Union claim similar honors. This is of some significance not only for nationalistic pride, but also since, historically, discovery has sometimes been an element in establishing sovereign rights.

Initial mention of the continent goes back to the ancient Greeks who postulated that a great southern land mass existed to ‘‘balance” the continents in the north. The Maoris of New Zealand also have vague legends of a white kind somewhere to the south, Maps produced in 16th century Europe depict an Antarctic continent, Terra Australis Re, which bears a strong resemblance to Antarctica on modem maps, yet historical records indicate the continent was not yet discovered.[2]

Documented Antarctic history begins with the voyages of Captain James Cook of the British Navy. Captain Cook sailed completely around the continent between 1772 and 1775. His two ships probed south at several points, but each time were turned back by heavy pack ice without sighting land. He did observe birds that he believed came from land further south. One significant accomplishment of Captain Cook’s in the Antarctic region was his discovery of South Georgia Island in the South Atlantic. Here he reported seeing fur seals, an observation which soon served as a magnet drawing American and British seal hunters further south.

It seems likely that seal hunters were the first to actually sight Antarctica. However, since they frequently kept their discoveries secret to protect their hunting areas, there are no existing records of the discovery of Antarctica before 1820. On January 30th of that year, a British ship under Captain Edward Bransfield reported sighting what may have been the mainland or what may have been an island off the coast of the Antarctic Peninsula. During the same year two Russian ships under the command of Admiral Thaddeus Bellingshausen sighted at several places what might have been land or might have been icebergs frozen in the pack ice, Bellingshausen would make no claim until he was sure. Finally, on January 28, 1821, he saw a mountainous coast that he named Alexander I Land. Alexander I Land has since been shown to be a large island separated from the continent.

Meanwhile, on November 18, 1820, the American Captain Nathaniel B. Palmer sighted the continent near the tip of the Antarctic Peninsula. On February 7, 1821, another American, Captain John Davis, sent

[1] Hereinafter referred to as the ‘‘~er~s Convention,’’ or, more simply, as the ‘‘Convention. ’

[2] J.G Weihaupt, “Historic Cartographic Evidence for Holocene Changes in the Antarctic Ice Cover, ” *Eos*, vol. 65, No. 35, Aug. 28, 1984, pp. 493-501.

a boatload of men to look for seals on the shore of what is now called Hughes Bay on the continent itself. Captain Davis wrote in his logbook, ''I think this Southern Land to be a Continent. "[3] He was right, but it took nearly 20 years before enough sightings had been made along the coast to be sure. The proof largely came from an expedition in 1838-42 led by Lieutenant Charles Wilkes of the U.S. Navy, who sighted land at numerous points along the coast over a distance of 1,500 miles. This was the first Antarctic expedition sponsored by the U.S. Government. The existence of a continent-sized land mass was firmly established by the early 1840's as two other expeditions (British under James Ross, and French under Dumont d'Urville) added their sightings of land at several other points around the coast of Antarctica.

Following the discovery period, there was little activity in Antarctica for the next 50 years. Interest renewed by the end of the century, spurred by new methods of whaling, scientific curiosity, and the spirit of adventure. The first expedition to winter over in the Antarctic was a Belgian expedition who spent the winter of 1898 aboard its ship which had inadvertently become frozen in the ice pack. The next year a British expedition spent the winter in a hut on land near the western entrance to the Ross Sea. These two expeditions began what has become known as the heroic period of Antarctic exploration during which the United States was relatively inactive in Antarctica.

In rapid succession followed the British National Antarctic Expedition under Captain Robert Scott (1901 04), the German Antarctic Expedition (1901-03), the Swedish Antarctic Expedition (1901-03), the Scottish National Antarctic Expedition (1902-04), the French Antarctic Expedition (1903-04), the British Antarctic Expedition (1907-09), the Second French Antarctic Expedition (1908- 10), the Amundsen expedition (1910-12), the second Scott expedition (1910-1 3), the Japanese expedition (191 1-1 2), a second German expedition (1911-12), the Australian Antarctic Expedition (191 1-14), and the British Imperial Trans-Antarctic Expedition (1914-16). Nearly all of these had some assistance from their governments, although contributions from scientific societies and wealthy industrialists were also important. Curiously, two of the earliest nations to explore Antarctica, Russia and the United States, were relatively inactive in Antarctica at this time. Tsarist Russia was preoccupied with wars, revolution, and an Arctic sea route to Siberia; the United States was preoccupied with the insular possessions it had acquired from Spain, Alaskan gold, and Arctic exploration. Increasing numbers of whalers were active in Antarctica during this time. Many of them investigated places not previously seen and mapped harbors and other features. In 1905-06, the Norwegians sent the frost factory ship to Antarctic waters, freeing whalers from the need for land stations. The remains of several whaling stations can still be seen on South Georgia Island.

The heroic period reached its climax in 1911 and 1912 when the South Pole was reached. The first to arrive was the Norwegian explorer, Roald Amundsen, and his party, followed a month later by Captain Robert Scott and four other Englishmen. Scott and his party perished on their return. When their remains were recovered a year later, they were found to have with them 30 pounds of rocks, gathered for their scientific value. World War I brought an end to the "heroic age" of Antarctic exploration.

The United States returned to Antarctica following World War I, and with that return came the modem era. The war had given rise to aviation, and aviation brought the United States to the forefront of Antarctic exploration, a position it retains to the present day. Airplanes were not the first machines in Antarctica. The heroic age had been served by the steamship, and tractors had been tried experimentally on the land. But the new generation of Antarctic explorers were aviators in search of exploits, as much as explorers eager to seize novel tools for geographic discovery.[4]

Between the heroic age and the International Geophysical Year (IGY) in 1957-58, the United States dominated Antarctic exploration. The leading figure of this effort was Admiral Richard E. Byrd. The Byrd expedition of 1928-30 was the first of a series of Antarctic expeditions in which Byrd and others, on behalf of the United States, saw, mapped, and claimed more land than expeditions of any other

[3]U.S. Antarctic Projects Officer, *Introduction to Antarctica*, January 1961, p. 12.

[4]S.J. Pyne, *The Icc, A Journey to Antarctica* (New York, NY: Ballantine Books, 1986), p. 96.

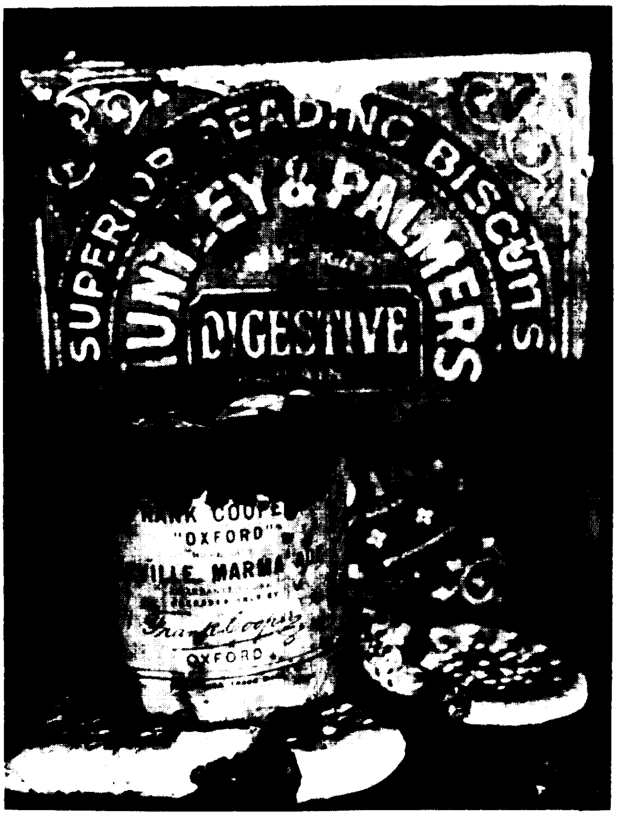


Photo credit. Steve Zimmer

Biscuits and marmalade, frozen for 75 years, inside Robert Scott's hut at Hut Point on Ross Island. The hut is preserved as a site of historic significance.

nation.[5] During this expedition Byrd and three companions became the first to fly over the South Pole, This expedition also made significant overland journeys and established that the continent was bisected by a single mountain range, now called the Transantarctic Mountains. Byrd led his second Antarctic expedition in 1933-35; his third, with the U.S. Antarctic Service, in 1939-41; his fourth, with the Antarctic Developments Project of the U.S. Navy, in 1946-48; and his last, as honorary chief of Operation Deep Freeze (which supported the American contribution to the IGY), in 1954-58.

Through Byrd's efforts an American presence was firmly reestablished in Antarctica, and a generation of explorers and scientists gained polar experience who would staff future American expeditions. By the time of the IGY, the United States had seen and established a basis of claim (although a U.S. claim has never officially been made) for 80 percent of Antarctica.[6] This area overlaps the claims of all of the other claimants and is symbolically reflected in the continuous U.S. occupation of a station at the South Pole. In addition, through the use of aircraft and the Pole station as an inland refueling site, the United States has maintained the capability to reach any point on the continent. The United States has sponsored more scientific research in Antarctica than has any other nation.

Another American Antarctic explorer to capture the imagination of the public was Lincoln Ellsworth. Ellsworth's ambition was to fly across the continent of Antarctica. In 1935, he succeeded in flying the length of the Antarctic Peninsula but was forced to land 16 miles short of his goal. Ellsworth and his pilot walked the rest of the way to Little America, Byrd's earlier base on the Ross Sea.

World War II brought a temporary halt to American activity in Antarctica. Following the war, despite emerging as a global power, the United States did not carry out its pre-war plan to establish permanent stations in Antarctica. Instead, the next American Antarctic activity was to mount a massive expedition in 1946-47 given the code name Operation Highjump. This expedition, involving 13 ships, 4,700 servicemen, and 51 scientists and observers was under the effective command of Rear Admiral R.H. Cruzen, although Admiral Byrd was Officer in Charge. Operation Highjump was the largest assault ever mounted in Antarctica. Participants in the expedition discovered more of Antarctica than all previous expeditions combined. The following year the U.S. Navy carried out a second expedition, called Operation Windmill. One of its major purposes was to relate aerial pictures taken the previous year to precise ground points so the areas discovered by Operation Highjump could be mapped accurately.

In 1950, a group of American and British scientists suggested a global International Geophysical Year during 1957-58 to correspond to a predicted period of unusual sunspot activity. The proposal was presented to the International Council of Scientific

[5] D. Shapley, *The Seventh Continent, Antarctica in a Resource Age* (Washington, DC: Resources for the Future, 1985), p. 34.

[6] Ibid., p. 62.

Unions (ICSU), which endorsed it in 1951. The 18-month IGY, which began on July 1, 1957, was the first world wide scientific effort to involve Antarctica. Previous cooperative efforts, the First and Second Polar Years (1882-83 and 1932-33) had stressed the Arctic. Now, however, advances in logistics and technology that had grown out of World War 11 made feasible geophysical studies in Antarctica. Consequently, Antarctica was a major element in the IGY.

Despite conflicting territorial claims in Antarctica and East-West tensions during the 1950s, the international cooperation achieved in Antarctica proved that scientific research could transcend political differences. The International Geophysical Year opend the "age of science" in Antarctica, which legacy continues.[7] A dozen nations participated in Antarctic studies, establishing 50 stations there. Today, there are 22 nations with substantial research programs in Antarctica. The International Geophysical Year activities in Antarctica made significant contributions to a number of fields, including upper atmospheric physics, glaciology, meteorology, and studies of the Earth's magnetic field. Seismic data were gathered and overland traverses were made by the United States, Soviet Union, Great Britain, and France. These countries obtained a wealth of information on ice temperature, density, and thickness; on surface elevations; and on magnetic and gravity fields, The United States established a station at the South Pole, which it has occupied year-round ever since. **By virtue of its technology, long history of Antarctic exploration, mapping, its extensive scientific research, and basis for a huge potential claim, the United States had become a dominant power in Antarctic matters.**

By the time the IGY was drawing to a close at the end of 1958, scientists and diplomats believed that the program in Antarctica was too valuable to terminate and that the international cooperation achieved during this period should be maintained. This common desire by the diplomats and scientists, particularly those of the United States, led to the conclusion of the Antarctic Treaty in 1959.

EVOLUTION OF THE ANTARCTIC TREATY SYSTEM

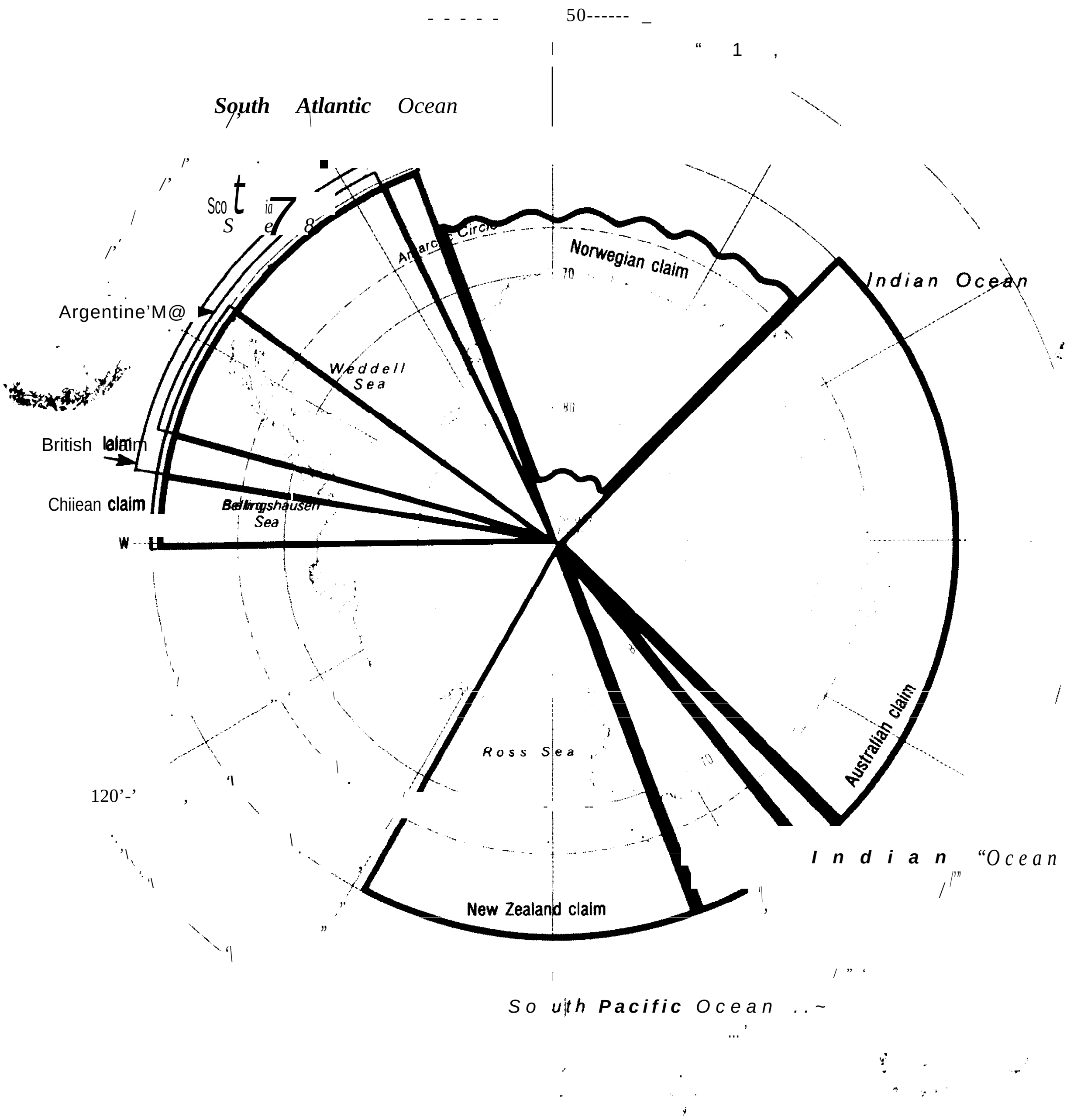
Seven countries claimed sovereignty over territory in Antarctica in the first half of the 20th century (figure 2-l). These countries are Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom. Several criteria, doctrines, or principles have been put forward as a basis of establishing territorial claims. One is discovery, which is the basis for the British claim to the Antarctic Peninsula and the France's claim in East Antarctica. The more common criterion is the sector principle, which is based on the concept of continuity or proximity under which some northern coastal nations claim offshore islands by extending boundaries from the ends of their main landmass toward the North Pole. Arctic islands, however, are nearby and geologically continuous with their respective landmasses of Asia and North America, whereas vast distances separate southern countries from their claims in Antarctica. Australia, New Zealand, Argentina, and Chile have invoked sector claims based on contiguity with Antarctica and sectoral extensions from their coasts. Another criterion is continuous occupation, also invoked by Argentina who has operated a weather station on Laurie Island since 1904. Norway also bases its claim to two islands and a coastal region on early occupation and use of the areas by its whaling captains.

The United Kingdom was the frost country to claim territory in Antarctica. It did so in 1908 by claiming a sector reaching to the Pole south of the Falkland Islands including the South Sandwich Islands, South Georgia, South Shetland, and South Orkney Islands, and the Antarctic Peninsula. This claim was further refined in 1917 to avoid inadvertently claiming part of the Chilean and Argentine mainland. New Zealand was the next claimant in 1923, soon followed by France in 1924 (France's original claim was to the coastal area but was enlarged to include a sector to the Pole in 1938), Australia in 1933, Norway in 1939, Chile in 1940, and Argentina in 1943.

All announced claimants except Norway have claimed wedge-shaped sectors terminating at the South Pole. Norway has claimed the coastal area

[7] Ibid., p. 16.

Figure 2-l—Antarctic Territorial Claims



Seven claims have been made to parts of Antarctica. The claims of Argentina, Chile, and the United Kingdom overlap in the Antarctic Peninsula area. One section of West Antarctica has never been claimed.

SOURCE: U.S. Government, 1989.

between 20° W. and 45° E., but has left the northern and southern boundaries of its claim vague, apparently to avoid undercutting its claim in the Arctic. The claims of three of the countries, Argentina, Chile, and the United Kingdom, overlap and conflict in the area of the Antarctic Peninsula, which is south of Cape Horn. Territorial claims in Antarctica have not received general recognition by the international community. Mutual recognition of claims has been limited to Australia, France, New Zealand, Norway, and the United Kingdom. Although Chile and Argentina do not recognize each other's claims, in 1941 they issued a joint declaration stating that the only countries with sovereignty over the Antarctic Peninsula are Chile and Argentina. **The United States and the Soviet Union have made no territorial claims in Antarctica and do not recognize the claims of others.** However, both have ''reserved" their ''rights" to assert claims in the continent. By not recognizing other claims and by placing one of its IGY stations in the middle of the large unclaimed sector and another at the South Pole where six claims converge, the United States became a strong moderating influence on the claims issue during the IGY. The Soviet Union provided an additional moderating influence by seeking a stake in the region rather than a specific territorial claim and by insisting on being part of any political solution.

The International Geophysical Year successfully submerged the issue of the territorial status of Antarctica to avoid political controversies that might be detrimental to scientific cooperation. Earlier, in 1948, the United States had proposed a solution to territorial claims in Antarctica through governance by a claimant condominium (which the United States would join by announcing a claim), but the proposal drew slight interest from only two of the claimants. In 1956, India presented a trusteeship proposal before the United Nations, but the proposal was unsuccessful. By then, the United States had abandoned the decision to announce a claim and was seeking a cooperative agreement along the lines of a plan by Julio Escudero Guzman of Chile (the Escudero proposal), who proposed a moratorium on the Antarctic sovereignty dispute while concentrating on scientific research.

It became clear to the 12 nations involved in Antarctic research that there would be a significant benefit if the work begun during IGY could be continued. On May 2, 1958, the United States proposed to the other participants, Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, the Soviet Union, the Union of South Africa, and the United Kingdom, that they should join ''in a treaty designed to preserve the continent as an international laboratory for scientific research and insure that it be used only for peaceful purposes. ' Preliminary talks in Washington were stalled by Chilean and Argentine reluctance to agree to international control and by Soviet objections to the existing Antarctic claims of other nations. A treaty was negotiated and signed on December 1, 1959. The United Kingdom became the first nation to ratify the Antarctic Treaty on May 31, 1960. United States ratification followed on August 18, 1960, and the treaty entered into force on June 23, 1961. The entire text of the Treaty, which contains only 14 articles, is presented in appendix C.

The Antarctic Treaty transformed a region beset by international rivalry to one characterized by peace and cooperation. Short, simple in its language, and deliberately lacking institutions, the Treaty has significantly diffused actual and potential disputes. The Treaty is administered through regular consultative meetings of all ATCPs, hosted by each participating nation in turn. The Treaty dealt with the most difficult question, sovereignty and nonrecognition of claims, in a simple and pragmatic manner. Article 4 provides that nothing in the Treaty shall be interpreted as a renunciation or diminution of a claim or basis for a claim and that no acts taking place while the Treaty is in force shall constitute a basis for supporting an existing claim or for establishing a new one. Any other attempt to resolve this issue, by opting for one solution or another, would likely have led to no solution at all and probably to continued rivalry.[9] Yet it is on the basis of this agreement that disputes about sovereignty have

[8] U.S. Congress, House Committee on Foreign Relations, Subcommittee on National Security Policy and Scientific Developments, *The Political Legacy of the International Geophysical Year*, Committee Print by Harold Bullis, Congressional Research Service, 1973, p. 57.

[9] F.O. Vicuna, "Antarctic Conflict and International Cooperation, " *Antarctic Treaty System: An Assessment* (Washington, DC: National Academy Press, 1986), p. 61.

Photo credit : Ann Hawthorn

Geodesic dome at the U.S. South Pole Station. The U.S. base is located at the convergence of the Antarctic claims.

come to be controlled. This same pragmatic approach also made possible the successful conclusion of the Antarctic Minerals Convention.

The original Parties to the Treaty were the 12 nations that were active in conducting research in the Antarctic during the International Geophysical Year of 1957-58 (table 2-l). They have the right to attend meetings provided for in article IX of the Treaty (consultative meetings) and are accordingly known as Consultative Parties. In addition, the Antarctic Treaty provides for other states who have acceded to the Treaty and have demonstrated significant scientific activity in Antarctica to become Consultative Parties. Ten additional countries have become Consultative Parties by this process. Only **Consultative Parties may participate in decisionmaking.**

On the basis of Treaty provisions and through consultative meetings a growing complex of arrangements for regulating activities of states in Antarctica has evolved. This complex of arrangements is known as the Antarctic Treaty System (ATS). It includes recommendations adopted at consultative meetings and separate conventions adopted at special consultative meetings. States party to the Treaty must give appropriate effect to the conventions and measures adopted pursuant to them. There have been nearly 150 agreed recommendations to governments since 1961. These cover a wide spectrum of activities in Antarctica including the following:

- cooperation in meteorology and in the exchange of meteorological data;

Table 2-l—Antarctic Treaty Nations
(In chronological order by year of accession)[a]

Consultative nations	Acceding nations
Original Treaty members (1959):	Poland (1961)[b]
	Czechoslovakia (1962)
Argentina	Denmark (1965)
Australia	The Netherlands (1967)
Belgium	Romania (1971)
Chile	German Democratic Republic (1974)b
France	
Japan	Brazil (1975)b
New Zealand	Bulgaria (1978)
Norway	Federal Republic of Germany (1979)b
South Africa	
Soviet Union	Uruguay (1980)b
United Kingdom	Papua New Guinea (1981)
United States	Itaiy (1981)[b]
	Peru (1981)
	Spain (1982)[b]
	People's Republic of China (1983)b
titer cosultative nations:	India (1983)[b]
Poland (1977)	Hungary (1984)
Federal Repubiic of Germany (1981)	Finiand (1984)
	Sweden (1984)b
Brazii (1 983)	Cuba (1984)
India (1983)	Republic of Korea (1 986)
Peopie's Repubiic of China (1985)	Democratic People's Republic of Korea (1987)
Uruguay (1985)	Greece (1987)
German Democratic Republic (1987)	Austria (1987)
	Ecuador (1987)
Itaiy (1987)	Canada (1988)
Spain (1988)	Colombia (1 989)
Sweden (1988)	

ah Of M I, 1888.
bNow consultative parties.

SOURCE: National Science Foundation, *Antarctic* Journal *of the United States*, vol. XXIII, No 4, December 1988, p 8; March 1989, p. 6.

- cooperation in telecommunications, including procedures for communicating among stations in Antarctica;
- cooperation in air transport and logistics;
- control of tourism, including development of guidance for visitors to Antarctica;
- a recommended code of conduct for stations in Antarctica and recommendations for developing procedures to assess impacts of operations; and
- the preservation of historical sites;

In addition, consultative meeting recommendations have led to the negotiation of separate agreements and conventions. In 1964 the parties to the Antarctic Treaty adopted the **Agreed Measures for the Conservation of Antarctic Fauna and Flora. The** original measures were supplemented in 1972 and 1985. As the Agreement now stands, its provisions:

- Forbid the killing, wounding, capturing, or molesting of native mammals or birds without a special permit.
- Oblige treaty members to minimize harmful interference with Antarctic living conditions and to alleviate pollution of nearshore waters.
- Protect biological communities within **Specially Protected Areas (SPAS)** where research, plant and animal collection, and vehicular access are denied. There are now 17 SPAS. Another 28 sites have been protected for research purposes through their designation as **Sites of Special Scientific Interest (SSSIs).** It is also likely that additional areas will be specially designated in the future for tourism and or multiple uses so that the impacts on these areas can be better controlled.
- Prevent the importation of nonindigenous species. Any such species must be issued a permit and kept under controlled conditions, removed from Antarctica, or destroyed.
- Encourage the alleviation of water pollution.

The United States ratified these measures in 1978 through passage of the **Antarctic Conservation Act** (Public Law 95-541). In accordance with this law, the Director of the National Science Foundation prescribes regulations, designates protected areas, and issues permits for actions that would otherwise be prohibited.

After some limited harvesting of seals in 1964, the 14 parties to the Antarctic Treaty drew up the **Convention for the Conservation of Antarctic Seals,** which was signed in 1972 and entered into force in 1978. The Convention totally protects the fur, elephant, and Ross seals from exploitation; prohibits the taking of seals that are in the water, except in limited numbers for scientific purposes; and sets annual quotas, seasons, and capture zones for crabeater, leopard, and Weddell seals.[10] Enforcement of the agreed-upon conservation measures depends entirely on the self-policing policies of the signatory nations.

[10] D.B. Siniff, ''Living Resources: Seals, *Oceanus*, vol. 31, No. 2, Summer 1988, pp. 71-74

The **Convention on the Conservation of Antarctic Marine Living Resources** (CCAMLR) was developed in the 1970s in response to heavy fishing and the consequent depletion of fish stocks. It entered into force in 1982 for all water within. about 1,000 miles of Antarctica.[11,12] The United States ratified this convention in 1984 through passage of the **Antarctic Marine Living Resources Convention Act** (Public Law 98-623). This convention encourages the study, management, and conservation of living resources within Antarctica's overall marine ecosystem, rather than focusing on individual species of commercial importance. Here again, each of the 23 nations signing the treaty is responsible for unilateral implementation of its provisions and any agreed-upon conservation measures.

Since its very beginning, the Antarctic Treaty System has been science oriented. The scientific community was instrumental in bringing the negotiators together to conclude the Treaty itself. A nongovernmental body, SCAR (Scientific Committee on Antarctic Research), that had been formed to coordinate IGY scientific activities in Antarctica, was made a permanent committee of the International Council of Scientific Unions even before the Treaty entered into force. The Scientific Committee on Antarctic Research continues to be an important vehicle through which scientists formulate and coordinate their research activities in Antarctica. Equally important, SCAR serves as a scientific advisory body to Consultative Parties. Recently, at the initiative of the United States, the Managers of National Antarctic Programs (MNAP) established itself as a new and separate organization to work in conjunction with SCAR. The Scientific Committee on Antarctic Research continues to frame research that is international in scope and MNAP considers the means of coordinating the implementation of meritorious projects. The Managers of National Antarctic Programs also reviews air safety, waste management, and other technological areas.

The system that has evolved under the Antarctic Treaty is both simple and pragmatic, which is also largely why it has been flexible and innovative in responding to challenges. In contrast to most other collective international undertakings, the Antarctic Treaty System has created new institutions and techniques only when necessary. This decentralized, evolutionary approach has permitted the institutions themselves to be tailored to the function they were designed to perform.[13] This functionally-oriented system demonstrates how Consultative Parties deal with new challenges, such as those generated by resource issues. Indeed, **the emergence of both living and mineral resource issues has been a major impetus to the evolution of the system and may well be the key to its future.**[14]

UNITED STATES ANTARCTIC INTERESTS

The first comprehensive statement of U.S. interests in Antarctica was issued by the National Security Council (NSC) in 1948, 11 years before conclusion of the Antarctic Treaty.[15] The National Security Council stated that:

- Antarctica shall be used for peaceful purposes only and shall not constitute a source of international discord;
- U.S. rights and interests throughout Antarctica must be protected;
- freedom of exploration and scientific research should be guaranteed;
- there should be free access to develop natural resources;
- activities in Antarctica should be guided by established nonpreferential rules; and
- sound orderly administration of the area should be established.

U.S. interests in Antarctica have evolved since 1948, but they have been characterized much more by continuity than by change. When in 1965 Harlan

[11] K. Sherman and A.F. Ryan, "Antarctic Marine Living Resources," *Oceanus*, vol. 31, No. 2, Summer 1988, pp. 59-63.

[12] Signatory nations to CCAMLR include the principal fishing countries of the world, including Japan with 13 percent of the world's catch, the Soviet Union with 12 percent, China with 8 percent, and Chile and the United States with 6 percent each.

[13] R.T. Scully, "The Evolution of the Antarctic Treaty System—The Institutional Perspective, *Antarctic Treaty System An Assessment* (Washington, DC. National Academy Press, 1986), p. 405.

[14] Ibid., p. 406.

[15] Office of Management and Budget, "The U.S. Antarctic Program," a report to the Committees on Appropriation of the U.S. Senate and House of Representatives, May 1983, app. A.

Cleveland, then Assistant Secretary of State for International Organization Affairs, articulated U.S. objectives, they were much the same as in 1948. Important new elements in 1965 were the U.S. support for the Antarctic Treaty—the vehicle which established an orderly administration for Antarctica-and the U.S. objective of making a special effort 'to preserve Antarctic animal and plant life.'[16]

Five years later President Nixon noted that U.S. interests consisted of maintaining the Antarctic Treaty and ensuring that Antarctica will continue to be used only for peaceful purposes and shall not become an area or object of international discord. U.S. interests would focus on fostering cooperative scientific research for the solution of worldwide and regional problems, including environmental monitoring and prediction and assessment of resources; and protecting the Antarctic environment and developing appropriate measures to ensure the equitable and wise use of living and nonliving resources.[17] Although this reformulation gives greater emphasis to U.S. environmental interests in Antarctica, the list is similar to those of 1948 and 1965, and remains essentially the same as of 1989.

U.S. interests in Antarctica can be grouped into four different categories: geopolitical and strategic, environmental, scientific, and economic.

Geopolitical and Strategic Interests

Since conclusion of the Antarctic Treaty in 1959, relations among states active in Antarctica have been relatively stable. This stability has been maintained despite the existence of fundamental legal and political differences regarding the status of Antarctica and the rights of states and private parties to conduct activities in Antarctica. Three basic political facts about Antarctica are central:

1. seven states have made territorial claims over parts of Antarctica, and some claims overlap;
2. the United States, the Soviet Union, and other nonclaimants do not recognize those claims, and assert a right (subject to their treaty obligations) for themselves and their nationals to conduct activities anywhere in Antarctica without being subject to the consent or control of a foreign government; and
3. the United States and the Soviet Union each believe that they have a basis for making a claim over Antarctica.

These facts give rise to two potential sources of conflict:

1. conflict between existing or future territorial claimants where claims overlap; and
2. conflict between territorial claimants and states that do not recognize the territorial claims.

The broader issue of potential conflict between rival blocs for military superiority in Antarctica looms in the background.

The Antarctic Treaty represents an attempt to minimize existing sources of conflict, avoid new sources of conflict, provide a framework for cooperation in the common interest, and address conflicts that may arise. It achieves this by demilitarizing Antarctica, opening all Antarctic areas and stations to inspection, providing for freedom of scientific research, preserving claimant and nonclaimant positions, and establishing a system for consultation and regulation of activities by the states concerned for scientific, environmental, and other purposes. It does not resolve the underlying differences regarding territorial claims but, in essence, attempts to sidestep them. Thus far, the Antarctic Treaty and related agreements that now comprise the Antarctic Treaty System have furthered U.S. interests in avoiding or minimizing conflict in Antarctica, and it is in the interest of the United States to continue to support these agreements.[18]

The greatest potential challenge to the system derives from the territorial claims. It would be naive to expect that the territorial claimants would long accept the compromise embodied in the Antarctic Treaty if they thought perfection of their territorial

[16] U.S. Congress, Subcommittee on Territorial and Insular Affairs, Committee on Interior and Insular Affairs, *Antarctic Report 1965*, Hearings, H. Rep. 89th Cong., 1st sess., *1965*, p. 30.

[17] Office of the White House Press Secretary, October 13, 1970, "U.S. Antarctic policy," Hearing, Subcommittee on Oceans and International Environment, Committee on Foreign Relations, U.S. Senate, 94th Cong., 1st sess., May 15, 1975, p. 30.

[18] J.D. Negroponte, "The Success of the Antarctic Treaty,' U.S. Department of State, Bureau of Public Affairs, Washington, DC, current policy No. 937, April 1987.

claims could be achieved at an acceptable price. Argentina and Chile, in particular, are subject to strong nationalistic pressures on the issue. A challenge for U.S. policy is to avoid encouraging perceptions abroad that U.S. opposition to foreign territorial claims is weakening.

Another potential threat to the stability of the system is posed by increasing interest in Antarctic minerals. This has revived the question of sovereignty and spurred interest in Antarctica by the United Nations General Assembly. The Antarctic Treaty System has succeeded in part because it limits participation in decisions to states that conduct significant levels of activity there. All Antarctic Treaty decisions are made by consensus, and key Minerals Convention decisions would be made by consensus. In general, the larger a decisionmaking group becomes, the more difficult consensus is to achieve. However, even as ATCPs worry about dilution of influence as participation grows, they have encouraged participation in the ATS as the only legitimate regime for Antarctica.

In general, U.S. political and strategic interests, particularly with respect to any system governing Antarctic mineral resources, would be promoted by seeking to:

- **maximize U.S. influence with respect to decisions regarding any aspect of Antarctica;**
- **maximize the influence of states substantially affected by the decisions being taken;**
- **avoid steps that could raise the expectations of the territorial claimants regarding special influence over their claimed areas; and**
- **discourage demands for global participation in decisionmaking.**

Environmental Interests

The Antarctic environment is unique and largely unspoiled: Antarctica supports unique wildlife; its ice comprises most of the world's fresh water; marine mammals and birds migrate there from great distances to feed on abundant krill and fish. However, much remains to be learned about Antarctic ecosystems and about the relationship of the Antarctic environment to the global environment,

Interest in preserving wilderness suggests no minerals activities at all should be allowed in the areas to be preserved. Careful study of potential environmental impacts and requirements is needed to minimize the impacts of minerals-related activities.

Environmental values are *potentially* at risk by any resource development allowed in Antarctica. Preservation of a vast wilderness on an increasingly settled and developed planet has esthetic, scientific, and moral value itself. Minerals development brings with it—as a trade-off against the benefits of the processed materials-infrastructure that has some unavoidable environmental impacts. Some mining techniques could alter the landscape for long periods. A significant oil spill from a rig or tanker could destroy many creatures and despoil significant areas for a long period of time given the slow rate of decomposition in frigid climates. Risks of accident in such a harsh climate are higher than in more amenable areas.

In general, these environmental interests suggest that the United States should:

- **maximize the incentives to observe sound environmental practices;**
- **maximize research and the disclosure of data about Antarctica; and**
- **with respect to the system governing Antarctic mineral resources, avoid direct or indirect incentives (e.g., the absence of taxes or royalties) that might make Antarctica more attractive for development than other parts of the world.**

Scientific Interests

Given its location and characteristics, and because it is largely uninhabited by man, Antarctica is a unique laboratory for scientific research. The information gained directly by scientists, and indirectly from others conducting activities in Antarctica, can greatly enhance knowledge not only about Antarctica but about natural processes and phenomena in general. Experience also demonstrates that new knowledge, no matter how remote from practical use it may seem at the time, can become the basis for significant practical developments in the future.

The availability of knowledge is maximized if minimum restrictions are placed on the conduct of scientific research, and if public release of data and information by scientists and others, including those engaged in resource activities, is encouraged. At the same time, the unique value of Antarctica as a pristine natural laboratory (e.g., for research on global climate change) is maximized if human activity that might significantly alter that environment is restricted.

In general, these interests parallel and reinforce environmental interests and have many formal expressions within the ATS. They also suggest the following objectives with respect to the system governing Antarctic mineral resources:

- **minimize interference with scientific research;**
- **maximize controls on minerals activity that may diminish scientific values; and**
- **maximize the incentives for disclosing data and information about Antarctica at all stages of minerals development.**

Economic Interests

It is not clear if or when extraction of Antarctic oil and gas or other mineral resources, if discovered, would prove attractive to investors. This depends in large measure on prices for the commodity, alternative sources of supply, and the value of a given resource deposit in comparison to the substantial investments required and risks posed by an extremely harsh and remote physical environment.

The United States shares with other consumers and importers of hydrocarbons and minerals an interest in assuring that Antarctic resources are available for extraction in response to market forces in order to meet world demand at minimum prices. The United States also has an economic, and to some extent political and strategic, interest in the diversity and security of its sources of supply of important commodities so as to avoid concentrated dependence on foreign sources subject to political or military disruption or manipulation. This interest generally points in the same direction as the consumer interest, although it may introduce a preference for greater involvement by American or allied companies.

In addition, the United States has an interest in maximizing the opportunities for productive economic activity by its nationals. This interest generally is advanced if extraction and processing of Antarctic mineral resources generates American employment and revenues directly or indirectly through utilization of American products and services.

The United States also has an interest in minimizing the costs of administering any system of governance for Antarctic mineral development. To the extent those costs are not passed onto miners, the American taxpayer will bear a share of those costs. To the extent the costs are passed on to miners, investment may be discouraged.

In general, these economic interests suggest the following objectives for the United States with respect to the system governing Antarctic mineral resources:

- **facilitate investment in response to market forces by establishing necessary ground rules, ensuring predictability and security of investment, and otherwise minimizing the restraints on investors;**
- **minimize the influence of governments or organizations hostile to the economic interests of United States over the resource regime;**
- **maximize the opportunity for investment by American companies; and**
- **minimize the cost of the system of governance.**

The present ATS serves U.S. interests in political stability, access to all of Antarctica now and in the future, participation in the regulation of Antarctic activities for environmental and other purposes, and avoidance of conflict with the Soviet Union or others. Moreover, the United States has been a leader throughout the development of the Antarctic Treaty System. The Antarctic Treaty itself is in large measure a U.S. proposal, and the United States has long pursued its interests in part through a policy of ''active and influential presence' on the continent. Continued U.S. participation in the ATS will help ensure a continued leadership role for the United States.

There is inevitably some tension among the different political, economic, scientific, and environmental interests of the United States in Antarctica. The Antarctic Minerals Convention, discussed in some detail in the next chapter, reflects judgments about the balance among conflicting U.S. interests, between the interests of the United States and other states involved in the negotiation, and about the relative priority to be accorded those interests,

WHY THE CONVENTION? WHY NOW?

Though historically there was little perceived need for rules concerning mineral resource exploitation in Antarctica, by the 1970s a combination of scientific, technological, and political factors began to change the Antarctic Treaty Parties' perception of the need for rules governing mineral resource development.

The sticky issue of the territorial claims was sidestepped in 1959 in order to reach a limited but still important agreement. The compromise, enshrined in article IV of the Antarctic Treaty, provided the glue which held the Treaty together and enabled the Parties to continue unhindered scientific research throughout Antarctica, prevent the continent's militarization, prohibit the use of Antarctica for disposal of nuclear waste, and, in general, promote cooperative activities.

By enabling scientists unhindered access to all parts of the continent, what was virtually *terra incognita* in 1959 was better known by the early 1980s. To be sure, scientists still have only "scratched the surface' of the 2 percent of the continent that is exposed, but they know that Antarctica is geologically similar to other continents under the ice. It contains occurrences of many minerals that, if found in large enough and rich enough deposits in relatively ice-free areas, would attract commercial interest. Scientists have also discovered that Antarctica was once a part of a supercontinent that has long since broken apart, now known as Gondwana or Gondwanaland.

Although there is evidence that Antarctica's continental shelves may contain oil and gas, no commercial drilling has been done, and whether any large hydrocarbon deposits exist is unknown. Commercial interest has also been dampened by the extremely difficult operating conditions that would be faced by producers in Antarctica. Nevertheless, many experts believe that if large deposits are found in Antarctica, they may one day be exploited.

Technology to exploit resources has improved significantly since the Antarctic Treaty was negotiated. For instance, technology has evolved for exploiting offshore oil—a resource that might be of particular interest if found in sufficient quantities in Antarctica (see app. A). Oil companies are venturing into ever deeper water in search for new prospects and into seasonally ice-covered areas of the Arctic and sub-Arctic. [19] Moreover, mining companies are already operating several mines in high latitude arctic areas of Alaska, Canada, Sweden, and the Soviet Union under conditions similar in some ways to those that would be found in some parts of Antarctica, notably the Antarctic Peninsula (see app. B). In some cases, for instance, in the case of a high-grade gold deposit in the Antarctic Peninsula, technology may already be available to profitably develop a high-grade resource. In most instances, at least some if not a significant amount of technology will still need to be developed before exploitation may proceed (particularly in environmentally sound terms and with regard to safety and economics). Nevertheless, technology developments are no longer seen to be a limiting factor.

As early as 1969 at least three inquiries were received by ATCP governments from companies interested in geophysical prospecting in Antarctica.[20] While prospecting does not normally require a legal system for protecting investments in a particular site, it does raise questions of the legal right to prospect and of environmental regulation. In theory, any territorial claimant might regard its existing domestic mining laws as applicable to its Antarctic territory. Yet, if it purported to regulate prospecting based on its territorial claim, it could provoke a dispute over the legal status of Antarctica.

[19] U.S. Congress, Office of Technology Assessment, *Oil and Gas Technologies for the Arctic and Deepwater*, OTA-O-270 (Washington, DC: U.S. Government Printing Office, May 1985).

[20] F.M. Auburn, *Antarctic Law and Politics* (Bloomington, IN: Indiana University Press, 1982), p. 243.

Similarly, if a nonclaimant purported to regulate prospecting in a claimed area, it could provoke a dispute. Thus, not only were no common and agreed procedures in effect at the time for issuing permits for prospecting activities, but the countries approached by commercial firms understood that if they issued permits unilaterally, they could upset the stability of the Antarctic Treaty.

In 1973 the price of oil rose dramatically, an event which further stimulated interest in Antarctica's resources by commercial firms and by ATCP governments.[21] Sometime in early 1975, for example, Texas Geophysical Instruments applied to the U.S. State Department for a permit to prospect in the Ross and Weddell Seas.[22] The permit was not issued.

Over the years the "claimants" and "nonclaimants' alike had developed a strong stake in the preservation of the Antarctic Treaty, which despite its shortcomings, has enabled unhindered scientific research and has kept Antarctica peaceful and demilitarized, The Antarctic Treaty Consultative Parties and other parties to the Antarctic Treaty were aware of new developments in science and technology and thus of the increased probability that at least a few potentially valuable deposits would possibly be discovered in the ice-free areas of Antarctica. Outside the ATCP group, some environmentalists expressed the hope that no resource development activities would ever be allowed in Antarctica. These groups argued that the mere existence of a minerals regime would unduly promote resource development there. Thus, in establishing a regulatory system, no matter how stringent its elements, legal uncertainty is removed, making it easier for potential developers to risk undertaking minerals activities. Few ATCPs were willing to consider banning all resource activities in Antarctica. They were convinced, however, that if no minerals agreement existed, disputes could arise over minerals. They feared that a major discovery in the absence of a regime would encourage a developer to proceed, subject only to its national laws or those of a territorial claimant.[23] Further, they perceived that they would be much more likely to reach an agreement before any major discoveries were made. The maintenance of political tranquility must therefore be viewed as a primary, although not exclusive, reason for negotiation of the Minerals Convention.

The Antarctic Treaty Consultative Parties began to respond to the gradual increase in interest about the resource potential of Antarctica by 1970. Initially, only informal discussions were held. The minerals issue first appeared on an ATCP meeting agenda at their seventh official meeting in 1972. At this time ATCPs agreed to initiate a study of the effects of mineral exploitation and to discuss this subject in more detail at the next regular ATCP meeting in 1975. During the interim, scientists aboard the *Glomur Challenger* discovered traces of natural gas near Antarctica,[24] OPEC (the Organization of Petroleum Exporting Countries) established its oil embargo, and the Soviet Union established a research base near the Dufek Mass if 'to prospect for minerals over a 5-year period.'[25] Also. a very rough estimate by the U.S. Geological Survey of the ''in place" oil and gas resources of Antarctica appeared in the press, for the first time making official figures of Antarctica's resource potential available.[26] The estimate, although based on virtually no data and since discredited, took on a life of its own and fueled speculation that Antarctica could be a significant new source of much-needed oil.

At the 1975 Consultative Party meeting, the ATCPs resolved to hold a special preparatory meeting on the sensitive minerals issue and directed the Scientific Committee on Antarctic Research to prepare a report on the environmental impact of minerals development,[27] The Special meeting, held

[21] Shapley, op. cit., footnote 5, p. 124.

[22] U.S. Congress, Subcommittee on Oceans and International Environment, Committee on Foreign Relations, ''U.S. Antarctic Policy,' Hearing, U.S. Senate, 94th Cong., 1st sess., May 15, 1975, p. 18.

[23] L.A. Kimball, *The Antarctic Minerals Convention*, Special Report of the International Institute for Environment and Development--North America, July 1988, p. 27.

[24] However, as pointed out in ch. 4, this likely has no significance with regard to the formation of petroleum.

[25] Auburn, op. cit., footnote 20, p. 80.

[26] Auburn, op. cit., footnote 20* p. 245.

[27] The report is known as the EAMREA report, for Environmental Impact Assessment of Mineral Resource Exploration and Exploitation in Antarctica. It was edited and published in 1979 by SCAR as "Possible Environmental Effects of Mineral Exploration and Exploitation in Antarctica."

in Paris in 1976, made it clear that the ATCPs had many differences about how to handle the minerals issue. One important result, however, was an informal moratorium on exploration and exploitation pending a timely solution to the problem. **A formal recommendation urging voluntary restraint while progress is made toward an agreed minerals regime was adopted by the ATCPs at the ninth Consultative Party meeting in London in 1977.**

Increasing attention was given to the minerals issue at the ninth and tenth Consultative Party meetings in 1977 and 1979, and recommendations concerning minerals were adopted at both meetings. Nevertheless, the development of a regime to regulate nonliving resources took a back seat to the question of living resources during this period. The Antarctic Treaty Consultative Parties tackled living resources first because some fishing and harvesting of krill was already occurring in Antarctica and increased unregulated exploitation-potentially enough to jeopardize some species-was expected. Also, living resources were judged by many to be a far easier issue with which to deal than nonliving resources, and successful negotiation of a living resources agreement might smooth the way for more difficult minerals negotiations.

A formal decision to negotiate a minerals regime for Antarctica was made at the eleventh ATCP meeting in Buenos Aires in July, 1981. Specifically, Recommendation XI- 1, which evolved from recommendations made at the previous two meetings, recommended that ‘‘a regime on Antarctic mineral resources should be concluded as a matter of urgency. ” The Recommendation endorsed the convening of a special consultative meeting (subsequently termed the Fourth Special Antarctic Treaty Consultative Meeting), and it established principles by which the new regime would be governed. The Antarctic Treaty Consultative Parties agreed that:

1. the Consultative Parties should continue to play an active and responsible role in dealing with the question of Antarctic mineral resources;
2. the Antarctic Treaty must be maintained in its entirety;
3. protection of the unique Antarctic environment and of its dependent ecosystems should be a basic consideration;
4. the Consultative Parties, in dealing with the question of mineral resources in Antarctica, should not prejudice the interests of all mankind in Antarctica; and
5. the provisions of article IV of the Antarctic Treaty should not be affected by the regime.[28]

Principles 2 and 5, in particular, express the ATCP’s desire that the new convention be an integral part of the Antarctic Treaty System, that it in effect strengthen the System by filling a significant gap in the collection of agreements governing Antarctica, Principle 5 recognizes the sensitivity of the claims issue, but also expresses the desire and willingness of ATCPs to negotiate a minerals regime that sidesteps the issue—just as was done in the living resources agreement. Principle 4 denotes in essence that the ATCPs consider that only those states with significant interests in Antarctica-the ATCPs themselves-should be involved in negotiating the new regime (but that they intend to ‘‘bear in mind” the interests of other countries). And principle 5 reveals one of the important reasons for negotiating. These basic principles are restated in a slightly different form in the preamble to the Minerals Convention.

THE ATCPs AND THE UNITED NATIONS

The Antarctic Treaty Consultative Parties do not view Antarctica as being similar to other uninhabited regions of the world-e. g., the seabeds beyond the limits of national jurisdiction-that may be susceptible to international management or control. **Because of the existence of claims and bases for claims and of the long history of successful administration of Antarctica, ATCPs have long held that they possess special rights and responsibilities there.** Some developing countries not party to the Antarctic Treaty actively dispute the view that a relatively small group of countries have earned the right to decide what is in the interests of the entire international community, what the ‘‘entry fee’ will be for Consultative Party status, or generally how Antarctica will be regulated. The Antarctic Treaty Consultative Parties have therefore vigorously resisted U.N. attempts to increase its influence in

[28]Recommendation XI-1, Antarctic Mineral Resources, paragraph 5.

Antarctica. The ATCPs contend that the Antarctic Treaty meets all criteria for a regional agreement under chapter VIII, article 52 of the United Nations charter and is thus consistent with the principles and purposes of the United Nations. In the early 1970s representatives of several developing countries tried to include Antarctica in the Law of the Sea discussions and to designate it, along with the deep seabeds, as part of the "common heritage of mankind, The ATCPs, including Chile and Argentina, the two original developing-country consultative parties, resisted these attempts.[29]

In the wake of the ATCPs decision to start negotiating a minerals regime for the continent and as the Law of the Sea negotiations were winding down at the end of 1982, the interest of U.N. members in Antarctica grew. The question of Antarctica was first placed on the U.N. General Assembly agenda in 1983, subsequent to a speech in which the Malaysian Prime Minister argued that the ''uninhabited lands' of Antarctica did not belong to the colonial powers claiming them and that it was time to negotiate a new international agreement for the continent.[30]

The Antarctic Treaty Consultative Parties have continued to resist any attempt to consider Antarctic issues in a broader forum. Each year, however, the question of Antarctica is considered in the U.N. General Assembly. Most recently, the General Assembly expressed "its conviction that any minerals regime on Antarctica, in order to be of benefit to all mankind, should be negotiated with the *full* participation of all members of the international community, ' and further expressed 'its deep regret that the Antarctic Treaty Consultative Parties have proceeded with negotiations and adopted [the Minerals Convention], '[31]

A global negotiation would challenge the underlying premise of the Antarctic Treaty, namely that decisionmaking should be limited to states with substantial scientific activities in Antarctica. Antarctic Treaty Consultative Parties perceive that this challenge could threaten the stability achieved by the Antarctic Treaty System. In part, the decision to complete an Antarctic Minerals Convention now, within the framework of the Antarctic Treaty System, represents an attempt to preempt efforts to deal with the question in the United Nations or some other multilateral forum.

Although ATCPs have been steadfastly unwilling to negotiate a new, more fully international agreement for Antarctica under the auspices of the United Nations, they have taken some steps to respond to U.N. concerns. They have, for instance, made information about their deliberations more available, enlarged the role of observers, and expanded relations with international organizations having scientific and technical interests in Antarctica. Over time, also, more countries have acceded to the Antarctic Treaty. Although the number of countries is still in the minority, 39 nations have now acceded, 22 of which are now also Consultative Parties. **With the addition of China and India, more than three-fourths of the world's population is represented. Moreover, virtually all countries with direct and substantial interests in Antarctica have acceded to the Antarctic Treaty and related agreements.** If the Minerals Convention is not ratified, U.N. efforts to establish an alternative regime could be given renewed impetus.

Concern about U.N. efforts to supplant the ATS was an additional reason for ATCPs to complete negotiations for a minerals convention. One final reason relates to the provision of the Antarctic Treaty that enables any of the Consultative Parties to call for a conference of all Parties to review operation of the Treaty beginning 30 years after its entry into force, that is, any time after June 23, 1991.32 The 1991 date is probably not as significant as some authors have suggested. Consultations among ATCPs are already extensive, occurring now at the biennial Consultative Meetings, at meetings of the Living Resources Convention, at meetings of the Scientific Committee on Antarctic Research, etc., as well as during negotiations of the Minerals Convention itself. Hence, ATCPs regularly review operation of the Treaty. Moreover, the possibility for amending the Antarctic Treaty at the review conference, as

29 Shapley, op. cit., footnote 5, p. 222.

30 Shapley, op. cit., footnote 5, p. 218"

31 United Nations General Assembly, 43d sess., "Quesuon of Antarctica, ' A/RES/43/83, Agenda Item 70, Jan. 26, 1989.

32 Antarctic Treaty, art. 12(2a).

suggested in article 12, can already be done at any time, and the process by which the Treaty could be amended in the review conference is the same as the process by which the Treaty is generally amended. **It will be as procedurally difficult to modify the Treaty in 1991, or thereafter, as it is now.**[33] Nevertheless, perceptions are important, and having a minerals regime in place before 1991 would be strong additional evidence that ATCPs are capable of dealing with problems as they arise. And, having just dealt with one of the most difficult issues threatening the stability of the Treaty System, ATCPs would be free to turn their attention to other important upcoming Antarctic matters.

[33] Shapley, op. cit., footnote 5, p. 231"

Chapter 3

The Convention on the Regulation of Antarctic Mineral Resource Activities

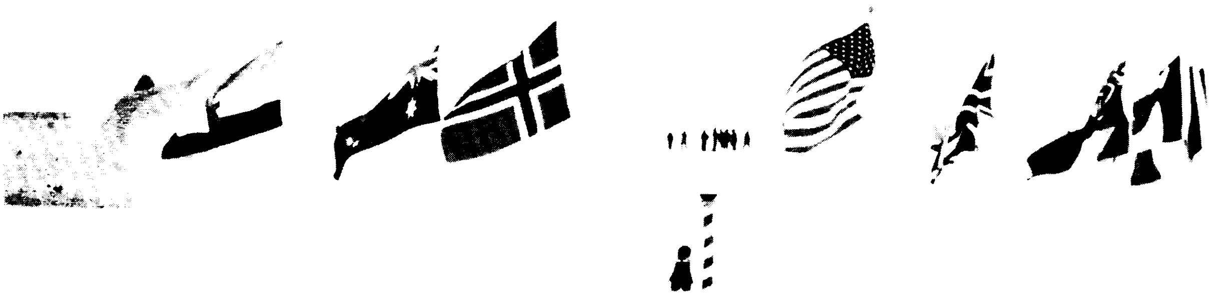


Photo credit: Ann Hawthorne

South Pole and Flags

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Chapter 3

The Convention on the Regulation of Antarctic Mineral Resource Activities

SUMMARY

The Convention on the Regulation of Antarctic Mineral Resource Activities creates the means for determining the acceptability of resource activities and for regulating any activities determined to be acceptable. It is a compromise agreement. Its final form is due in large part to the fact that seven claims have been made to parts of Antarctica, but that no other states accept the validity of those claims. It is also a result of the need to find a way to balance the interest of many countries in protecting Antarctica's environment, yet still allow for the possibility of minerals development in and around the continent. The attempt to balance competing interests is key to understanding the composition, voting procedures, decision-making authority, and other checks and balances established by the Minerals Convention. It is also key to understanding provisions for regulating resource activities and protecting the environment. The Convention is not intended to promote resource development: it seeks to be neutral, neither promoting nor prohibiting development.

The Minerals Convention is intended to be an integral part of the Antarctic Treaty System (ATS). It compensates for the fact that the Antarctic Treaty does not address mineral resource questions. If left unaddressed, the Treaty Parties believe this omission could lead to instability and possibly a breakdown of the ATS. Such a breakdown is not in the interest of the United States: on the contrary, the United States has long held the ATS as a model of effective international cooperation.

The Minerals Convention is a framework regime. It does not contain a detailed mining code but relies on general guidelines and some specific requirements and prohibitions, much as a general statute delegating authority to an administrative agency might do. The Parties avoided detail because of the difficulty of anticipating all regulatory requirements. The institutions created in the Minerals Convention, in particular the Commission and the Regulatory Committee(s), will be responsible for establishing details of the regime.

The Minerals Convention contains potentially strong environmental protection provisions. For instance, binding dispute settlement procedures will apply to all measures related to environmental protection. The principal uncertainties regarding environmental protection are how well the compliance and enforcement provisions of the Convention will work in practice and what terms such as ''adequate and ''significant" mean in relation to environmental measures.

The hurdles a potential minerals developer would have to clear before a proposed development could proceed are demanding. Initiating exploration and development under the terms of the Convention will be difficult. However, commercial enterprises recognize that they are better off with a minerals agreement than without one.

Minerals prospecting, exploration, and development must be sponsored by a Party to the Convention. Sponsoring states must evaluate Operators they sponsor and oversee their activities. Sponsors must also be prepared to support and defend the interests of their Operators in institution meetings.

One of the most difficult issues the Antarctic Treaty Consultative Parties (ATCPs) faced was the issue of liability for activities that result in damage to the Antarctic environment. The Minerals Convention contains general liability provisions, but the ATCPs must negotiate a separate Liability Protocol before any exploration and development can be considered in Antarctica. Prospecting may proceed, subject to the general liability provisions of the Convention.

Ratification of the Minerals Convention would advance important U.S. environmental, scientific, economic, and political and strategic interests in Antarctica. For different reasons, development-minded and environmental groups see the Convention's lack of detail as a shortcoming. In the long run, this concern may be less important than whether the Convention helps to maintain peace and stability in the region.

INTRODUCTION

The Antarctic Treaty Consultative Parties (ATCPs) recognized in the 1970s that an agreement about potential minerals activities in Antarctica eventually would be needed. They perceived that knowledge about Antarctica's geology was steadily increasing, that the technical feasibility of developing any mineral resources that might be found in Antarctica was improving, and that a major resource discovery in the absence of an agreed regime for managing minerals activities could lead to a weakening of the Antarctic Treaty System. A formal agreement to establish an Antarctic minerals regime was made at the ATCP's 1981 Buenos Aires meeting. It was not immediately apparent, however, that a mutually acceptable agreement could be reached. While the ATCPs were generally agreed that the ATS must be preserved and that the Antarctic environment must be protected, not all Treaty parties had the same view about how to accomplish these and other ends. How would the interests of claimant and nonclaimant states be balanced without compromising the juridical positions of either? Could Antarctica's environment be adequately protected (and if so, how) without banning all minerals development there? How were revenues derived from any permitted minerals activities to be divided? Who would pay (and how much) in the event of an accident such as an oil spill? The Convention on the Regulation of Antarctic Mineral Resource Activities addresses these and other issues. This chapter describes and evaluates this new treaty.

The Minerals Convention was adopted on June 2, 1988, after 6 years of negotiations. It applies to the same area as the Antarctic Treaty, or all land, ice shelves, islands, and continental shelves south of 60° s.[1] The Convention creates the means for determining the acceptability of mineral resource activities and for regulating any activities determined to be acceptable. The 67 main articles and 12 annex articles of the Minerals Convention establish the general principles, specify the legal obligations of the Parties, and create the institutions and procedures necessary for decisionmaking. **In effect, Parties to the Convention have said that in some circumstances Antarctica% resources may be developed, but only if significant environmental impacts are unlikely to result from development and only if established uses of Antarctica are not jeopardized.**

The Minerals Convention does not automatically open Antarctica to resource development activities. Although the Convention does not prohibit the possibility of developing any mineral resources discovered in Antarctica, neither is it intended to promote development. Indeed, certain standards and procedures established by the Convention impose stringent requirements on resource development considered acceptable. Second, the Minerals Convention does not automatically close all of Antarctica to resource development, While development of those parts of Antarctica designated as Specially Protected Areas (SPAs) or Sites of Special Scientific Interest (SSSIs) is automatically prohibited, all other areas may be considered for development activities. Many of the areas considered for resource development will be eliminated, however, if it is determined that development would have significant adverse effects on the environment or on scientific or historic values. Obviously, the Minerals Convention does not completely satisfy those intent on preserving all of Antarctica in a pristine state, nor does it completely satisfy potential developers, who would benefit from a less restrictive regime regulating access to the continent. Third, the Minerals Convention is not intended to be a detailed mining code, specifying how all possible situations are to be handled and eliminating all uncertainty. It is intended, rather, that more detailed rules and regulations will be developed when and if necessary by the institutions established by the Convention. Thus, it is a framework regime, to be considered as another step forward—not the final step-in the evolution of the Antarctic Treaty System.

The Minerals Convention is a carefully crafted compromise. Negotiators had the difficult task of dealing with the differing juridical positions of claimants and nonclaimants and of balancing the interests of developed and developing states, of states with free market and centrally planned economies, and of states with varying attitudes about the environment. The relative importance of competing ''uses' of Antarctica-minerals development, science, tourism, pristine wilderness, etc.—also had to

[1] An exception is continental shelves south of 60" S. which extend from islands north of 60° S.

be considered. As a result, the Minerals Convention is a complicated agreement, despite its framework nature. Like similar multilateral agreements, it was negotiated as a package deal. That is, the United States and other participants in the negotiations must now either accept the Convention as it is or reject all of it. Changes in the Convention will not be considered. Table 3-1 indicates what must occur before minerals development can commence in Antarctica.

An explicit hierarchy of actors with a stake in Antarctic minerals issues exists. At the top of this hierarchy are the Antarctic Treaty Consultative Parties or ATCPs. The ATCPs are the most influential set of Antarctic actors and the only group with rights to participate in decisionmaking under the terms of the Antarctic Treaty. ATCPs, as of November 25, 1988, are automatically accorded decisionmaking status under the Minerals Convention.[2] At present, there are 22 ATCPs.[3] They are the original 12 signatories of the 1959 Antarctic Treaty and the 10 additional states that have subsequently demonstrated a special interest in Antarctica through the conduct of substantial scientific research there. Seventeen other Parties to the Antarctic Treaty do not have Consultative Party status. However, any Party to the Antarctic Treaty, in addition to ATCPs, may become a Party to the Minerals Convention (and any member of the United Nations may become a Party to the Antarctic Treaty). On June 2, 1988, 13 of the then 16 non-ATCP Parties to the Antarctic Treaty adopted the Minerals Convention along with the ATCPs. All Parties to the Minerals Convention may participate in the Scientific, Technical, and Environmental Advisory Committee and in the Special Meeting of Parties, but these institutions do not have any decisionmaking authority. Any Party to the Minerals Convention, which undertakes substantial minerals-related research or which sponsors exploration or development, may participate in the decisionmaking organs of the Convention while it is carrying out these activities. Observer status to the Commission and Advisory Committee established by the Minerals Convention is open to any Party to the Antarctic Treaty not participating in the Minerals Convention and may be accorded, as appropriate, in the Commission, the Advisory Committee, and the Special Meeting of Parties to international organizations, including non-governmental organizations, with special interests in Antarctica. Only other Parties to the Minerals Convention may send observers to Regulatory Committee meetings,

Two other types of actors play significant roles in the Convention. A Sponsoring State—one sponsoring resource activities-may be any Party to the Minerals Convention, regardless of ATCP status. Operators—those undertaking resource activities—must be sponsored and may be a Party, an agency of a Party, a juridical person established under the law of a Party (e.g., a corporation), or a joint venture consisting of any combination of these entities.

GENERAL PRINCIPLES

Several important general principles are established in chapter 1 of the Convention. Among the most important is that the Convention is an integral part of the Antarctic Treaty System, in effect filling a gap in it. As part of the ATS, Parties strove to make the Convention consistent with other agreements of the system, including the Antarctic Treaty and the Convention on the Conservation of Antarctic Marine Living Resources (art. 10). Parties considered it especially important **that their positions on territorial claims continue to be protected,** and thus article 9 of the new treaty essentially repeats article *4* of the Antarctic Treaty, the modus vivendi employed to sidestep the claims issue. The Minerals Convention, thus, does not resolve conflicts over claims, but provides the means by which resources may be developed (or at least considered for development) despite differences. If the Convention is successfully implemented, it would be unnecessary to resolve the claims issue, which may be unsolvable in any case, and the unique jurisdictional arrangement in Antarctica would continue as before.

One important way in which the Minerals Convention is directly tied to the Antarctic Treaty is that those Parties to the Minerals Convention that were also Consultative Parties to the Antarctic Treaty on the date the Convention was opened for signature (20 of the current **22) are** automatically entitled to

[2]New ATCPs will be accorded decisionmaking status in the Commission unless one-third of commission members object. Art. 18(4).

[3]Argentina, Australia, Belgium, Brazil, Chile, China, Federal Republic of Germany, France, German Democratic Repulic, India, Italy, Japan, New Zealand, Norway, Poland, South Africa, Spain, Sweden, Union of Soviet Socialist Republics, United Kingdom, United States, and Uruguay.

Table 3-I-What Must Occur Before Exploration and Development Can Take Place In Antarctica

1. The Minerals Convention must be formally signed. Signature may take place during a l-year period beginning Nov. 25, 1988,[a] The 20 Antarctic Treaty Consultative Parties (ATCPs) and 13 Non-Consultative Parties (NCPs) that participated in the last session, where the Convention was adopted by consensus, are eligible to sign. The United States signed the Convention on Nov. 30, 1988.

2. The Minerals Convention must be ratified by 16 of the 20 ATCPs that adopted it. Among the 16 must be 11 developed and 5 developing ATCPs. Also among this group must be all 7 of the ATCP claimant countries; the United States and the Soviet Union (the 2 non-claimants that reserve the right to make a claim); and at least an additional 7 non-claimant ATCPs, 3 of which must be developing nations. This configuration assures participation by all of the states necessary to meet the membership requirements of ail of the Convention's institutions. The ratification process could take several years.[b]

3. A Protocol to the Minerals Convention elaborating additional rules and procedures regarding liability must be negotiated and ratified in the same manner as the Minerals Convention. Negotiations to complete the Protocol could begin in 1989 or 1990. They may take several years.[c]

4. The Commission must consider adopting additional measures related to, inter alia; a) protection of the Antarctic environment; b) safe and effective expiration and development techniques; c) prospecting; d) the availability and confidentiality of data; e) maximum block sizes; f) the circumstances under which Management Schemes may be suspended, modified, or canceled; g) financial regulations; h) fees payable for applications; and 1) levies payable by Operators engaged in exploration and development. [d]

5. Prospecting would likely take place. Some prospecting may occur before the Liability Protocol is completed. It can be done without prior authorization by the institutions established by the Convention and is subject to the same standards of acceptability as expiration and development."

6. On behalf of an Operator, a Party to the Convention must propose a specific geographic area of Antarctica to be opened for expiration and development. This would be expected to occur once some prospecting had been done by one or more Operators and areas of interest had been identified.[f]

7. Once an area is proposed, a consensus decision to open the area must be made by the Commission. Supporting information, including a detailed environmental impact assessment, must accompany a request to open an area. Information adequate to enable informed judgments must be available. The Commission must elaborate opportunities for joint ventures or other forms of participating.[g]

8. The environmental assessment must conclude that the activity will not result in any *significant* adverse environmental impacts; that technology and procedures are available for safe operations and for compliance with environmental regulations; that the capacity exists to monitor key environmental parameters and ecosystem components; and that the capacity exists to respond effectively to accidents.[h]

9. Following the Commission decision to open an area, and before any specific applications to conduct exploration/development may be considered, the Regulatory Committee for the particular geographic area must be established. The Committee must draft general requirements governing applications and terms and conditions, giving effect to the standards in Article 4.[i]

10. Inspection procedures must be provided for each area identified for possible expiration and possible development.]

[a] Art. 60.
[b] Art. 62 and the Final Act.
[c] Art. 8(7).
[d] Art. 21.
[e] Art. 37
[f] Art, 39,
[g] Art. 39 and 41.
W. 4.
[i] Art. 43(3).
[j] Art. 12(8).

SOURCE: Office of Technology Assessment, 1989.

membership on the Commission established by the Convention. Membership is also granted non-ATCP Parties *currently* sponsoring exploration or development or *currently* engaged in research related to the Convention (art. 18(2)). Only these ATCPs have automatic voting privileges and the right to participate in many key decisions.

To further promote consistency with other elements of the Antarctic Treaty System the **Parties specified that all decisions should take into account the need to respect other established uses of Antarctica, including scientific research, long the most important activity there; the conservation-including rational use-of marine living resources; and tourism, an important and rapidly growing activity. The** Convention makes clear that the Parties must consider possibly conflicting established uses in determining whether to open an area to exploration and development (art. 41(lb)). The Convention grants inspectors designated according to rules established in the 1959 Antarctic Treaty rights to inspect all stations, installations, equipment, etc. related to minerals activity in the Antarctic Treaty area. It also provides for the designation of inspectors by each member of the Commission and by the Commission as a group. Thus, consistency with the inspection provisions of the Antarctic Treaty is also promoted.

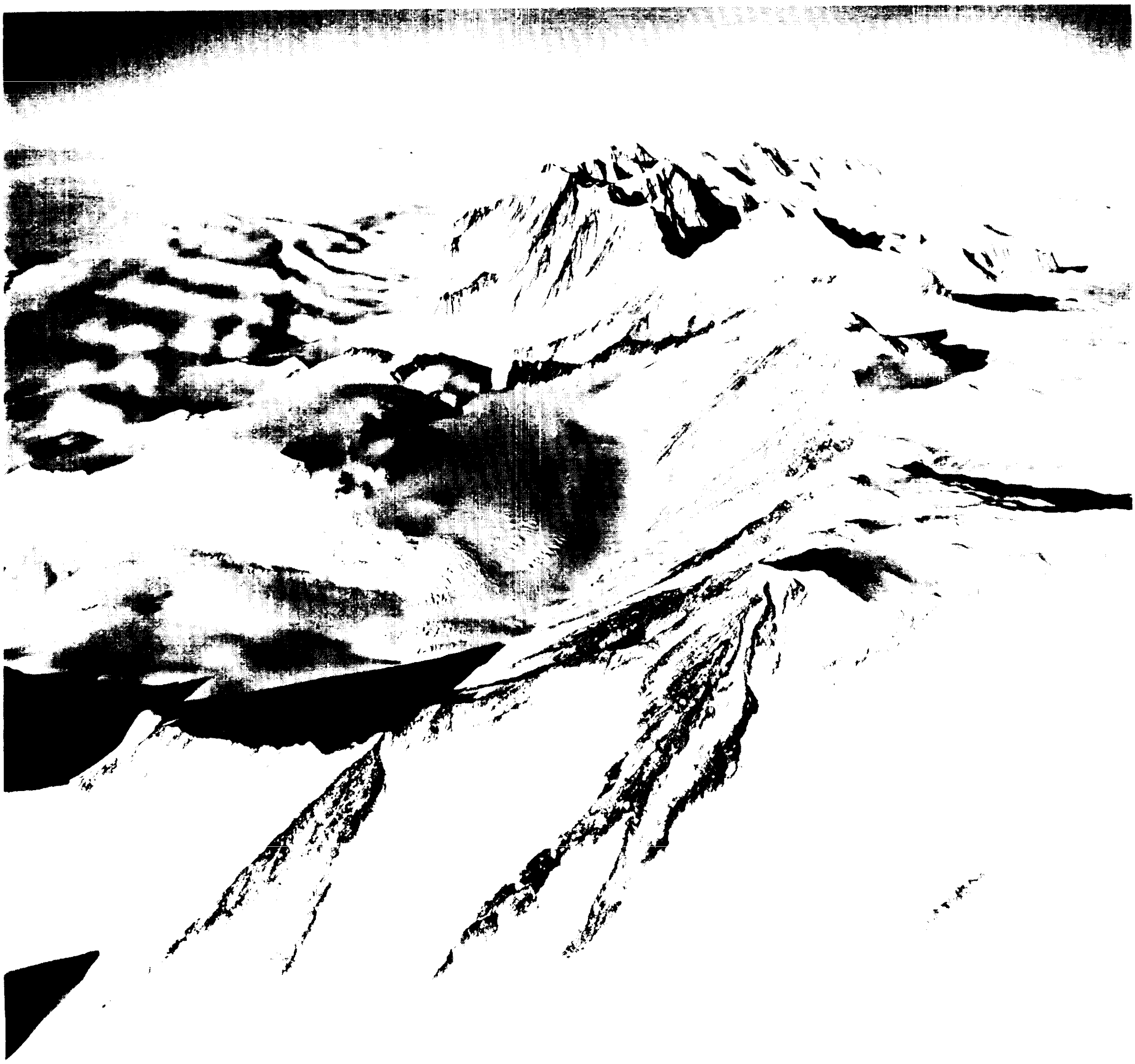


Photo credlt US. Geological *Survey*

Looking north along the western side of the Sentinel Range. Located near the base of the Antarctic Peninsula, the highest mountains in Antarctica are found here.

Another important general principle is that **no exploration or development may take place unless specifically authorized. The** standards and process for authorizing exploration and development take up much of the Convention. This principle is the opposite of the exploitation principle established for **the** marine living resources of Antarctica under the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), wherein fishing activities are deemed acceptable unless specifically prohibited. The prohibition of resource activities unless authorized would not affect activities by countries that are not party to the Minerals Convention. While in theory this could be a problem, in practice virtually all countries that have the capability to exploit resources in Antarctica were involved in negotiating the Convention. Moreover, as long as the Convention retains its legitimacy, any attempt to exploit resources outside the Minerals Convention would be looked on with disfavor by the Parties and would probably not succeed. Prospecting, unlike exploration and development, does not require specific authorization.

As a general rule, **authorization for a specific project depends on a finding that the project will not cause significant adverse effects on atmospheric, terrestrial, or marine environments,** including significant effects on:

- air and water quality;
- species of flora or fauna;
- endangered or threatened species; and
- biological, scientific, historic, aesthetic, or wilderness areas of special significance (art. 4).

Cumulative effects are also to be taken into account, as are activities that could cause significant adverse effects on global or regional climate or weather patterns. Interpretation of the term "significant impacts' is left up to the Commission or Regulatory Committee members, as the case may be, with advice from the Advisory Committee. **Authorization for an activity also depends on the existence of adequate technology, the ability to monitor key environmental parameters, and the ability to respond effectively to accidents.**

INSTITUTIONS

The Minerals Convention provides for the establishment of five institutions (i.e., a Commission, Regulatory Committee(s), an Advisory Committee, an Arbitral Tribunal, and a Secretariat) and a Special Meeting of Parties. Table 3-2 identifies membership, decisionmaking authority, voting procedures (if applicable), and key functions for each of these institutions.

The Commission

The Commission is one of the two decisionmaking institutions established by the Minerals Convention and the only one to which all of the Parties eligible to participate in making decisions belong. Unlike the Regulatory Committees, which wield authority only within designated areas of Antarctica, the authority of the Commission extends to all of the area covered by the Minerals Convention. The Commission has broad authority for establishing general rules and procedures applicable to all prospecting, exploration, and development, and to dispute settlement. Many of the details for these processes have not yet been elaborated, so the Commission will have much important work to do if the Minerals Convention is ratified. The Commission is also charged with determining the composition of Regulatory Committees and with reviewing some of their actions. One of the Commission's most important responsibilities is to determine, by a consensus vote, whether or not to identify an area for possible exploration and development for a particular resource. An affirmative decision would trigger the process that could ultimately result in developing a deposit.

Regulatory Committees

If the Commission decides to "identify" (open) apart of Antarctica for exploration and development, a Regulatory Committee will be appointed by the Commission for that area. Regulatory Committee members are chosen from the Commission and thus form a subset of Commission members. This subset is selected to include Parties with knowledge of the particular area and to achieve a political balance, particularly between claimants and nonclaimants and between developed and developing countries. Each Regulatory Committee is responsible for formulating detailed requirements for exploration and development within its area consistent with the general guidelines established by the Commission. The Regulatory Committees, therefore, and not the Commission, will be the primary managers of any exploration and development that may occur within the identified area.

As the primary managing bodies, Regulatory Committees will have the power, among other things, to set general requirements for the conduct of exploration and development within the designated area, to issue or deny exploration and development permits, to devise Management Schemes (contracts), and to suspend, modify, or cancel Manage-

Table 3-2—The Institutions of the Convention

The Commission

Membership: 1) All Antarctic Treaty Consultative Parties—there are 22-as of Nov. 25, 1988; 2) Any other Party that undertakes substantial research relevant to decisions about mineral activities; 3) Any Party that sponsors exploration or development *during* the *period that the relevant Management Scheme for the exploration or development is in force.* Art. 18.

Decsionmaking authority Yes.

Voting Procedures Consensus voting on the decision to identify an area for exploration and development, on budgetary matters, and on elaboration of the principle of non-discrimination; three-quarters majority of the members present and voting on matters of substance; a simple majority of members present and voting on procedural matters. Art. 22.

Key functions:

- To designate areas in which resource activities shall be prohibited or restricted. Arts. 13(2) and 21 (lb).
- To adopt measures for the protection of the Antarctic environment. Art. 21(c).
- To determine whether or not to identify (open) an area for possible exploration and development. Arts. 21 (Id), 41, and
- To adopt general measures relating to prospecting. Arts. 21 (1 e) and 37(13).
- To establish and determine the composition of Regulatory Committees. Arts. 21(1 k) and 29.
- To review the actions of Regulatory Committees, in particular, decisions to approve Management Schemes or to issue development permits. Arts. 21(1 1) and 49.
- To adopt measures related to international participation and joint ventures, especially with developing country Parties. Arts. 6, 21(1 m), and 41 (id).
- To adopt general measures relating to the circumstances under which Management Schemes may be suspended, modified, or canceled. Arts. 21(1 n) and 51(6).
- To make decisions on budgetary matters and to adopt financial regulations. Arts. 21(1 o) and 35.
- To adopt measures regarding fees and levies payable by Operators. Arts. 21 (1p) and 21 (1q).
- To draw attention to activities by Parties that affect compliance with Convention obligations. Arts. 7(7) and 21(1 s).
- To determine the disposition of revenues. Art. 21 (r).
- To establish additional procedures for third-party dispute settlement. Arts. 21(v) and 59.
- To adopt measures on availability and confidentiality of data and information. Arts. 16 and 21(1 h).

Regulatory Committees

Membership: 1) Each Committee to consist of 10 members selected from the group of Commision members, 4 of which must be claimants and 6 of which must be non-claimants. Included on all Committees formed must be: a) the member(s) that have made claims in the area being considered; and b) the United States and the Soviet Union, neither of which have made claims but both of which assert a basis of claim in Antarctica. Three of the ten members must be developing countries. In addition to the basic 10: 2) the Commission member that proposed opening the area If that member is not otherwise a member of the Committee, until such time as an application for an exploration permit is lodged; 3) Parties that lodge exploration permits during the period the application is being considered; and 4) Parties whose applications result in approved Management Schemes for as long as the Management Scheme is in force, Art. 29.

Decisionmaking authority Yes

Voting procedures: A two-thirds majority of those present and voting for key votes (i.e., approval of Management Schemes or of modifications to Management Schemes), the two-thirds majority to include both a simple majority of the claimants and a simple majority of non-claimants on the Committee; a similar "chambered" two-thirds majority, with "at least half" from each chamber for decisions concerning adoption or revisions of general guidelines for exploration and development; a simple two-thirds majority on other matters of substance; a simple majority of those present and voting on procedural matters. Art. 32.

Key functions:

- Subject to general measures adopted by the Commission, to prepare for managing the area for which it was formed, i.e., to divide the area into blocks, to establish fees and procedures for handling applications, and to determine a method of resolving competing applications. Arts. 31(a) and 43(2).
- To adopt general guidelines for exploration and development, Arts. 21 (la), 43(3), and 43(5).
- To consider applications for exploration and development. Art. 31 (lb).
- To issue exploration permits and approve Management Schemes, the specific terms and conditions for exploration and development. Arts. 31(1c) and 44-48.
- To issue development permits. Art. 54(5).
- To monitor exploration and development activities. Art. 31(d).
- To suspend, modify, or cancel Management Schemes if it is determined that unanticipated and/or unacceptable impacts have resulted or are about to result. Arts. 31(1 e), 51, and 54.

The Scientific, Technical, and Environmental Advisory Committee

Membership: All Parties to the Convention. Art. 23.

Decisionmaking authority No.

Key functions:

- To provide advice on scientific, technical, and environmental issues to the Commission and Regulatory Committees. Arts. 26(2), 26(3), 27, 40(1), 43(6), 45(3), 51(2), 52, and 54(6),
- To evaluate environmental and technical assessments to assist decisions by the Commission and Regulatory Committees. Art. 26(4).
- To provide advice to interested developing country Parties and other Parties on issues within its competence, including training programs related to scientific, technical, and environmental matters bearing on Antarctic mineral resource activities and opportunities for cooperation *among* Parties in these programs. Art. 26(6).

The Arbitral Tribunal

Membership: One arbitrator from the Party commencing the dispute proceedings; one arbitrator from the other Party to the dispute; a third arbitrator chosen jointly by the parties to the dispute (from a list of arbitrators composed of representatives from each Party to the Convention, as are the other two) and unconnected to either of the Parties. Where there are more than two parties to the dispute, the Parties having the same interest appoint one arbitrator. Annex Art. 3.

Decisionmaking authority: Yes--for those disputes referred to it.

Voting procedure: All decisions in areas within its competence by majority vote; all arbitrators must vote. Annex Art. 12.

Key functions: To resolve disputes between two or more parties. Annex Art. 10.

Continued on next page

Table 3-2-The Institutions of the Convention-Continued

The Secretariat Key ***function:*** To serve the Institutions of the Convention. Special ***Meeting*** of parties ***Membership:*** All Parties to the Convention, Art. 28(2). ***Decisionmaking authority No.*** *Key function:* . To consider whether identification of an area for exploration and possible development by the Commission is consistent with the Convention, Arts. 28 and *40(3)*.	***Comment*** The Special Meeting of Parties gives an opportunity to all Parties-not just those who have qualified to participate in the decision-making institutions-to express their opinions about whether exploration and development in areas being considered for "identification" would be consistent with the principles of the Convention.

SOURCE: Office of Technology Assessment, 1989

ment Schemes. Some of the decisions of the Regulatory Committees are subject to review by the Commission, but the Commission is limited in its ability to require Regulatory Committees to alter decisions. Other Regulatory Committee decisions are subject to binding dispute settlement.

The Scientific Technical, and Environmental Advisory Committee

This committee, to be composed of representatives with relevant specialized expertise, was established to give expert advice to the Commission and Regulatory Committees on all scientific, technical, and environmental aspects of minerals resource activities. The Committee also provides a forum for consultation and cooperation for the collection, exchange, and evaluation of information. One of the most important functions of the Advisory Committee is to evaluate comprehensive environmental and technical assessments of proposals to open areas to exploration and development and of exploration and development plans (art, 26(4)). Membership is open to all Parties-that is, to Convention signatories without voting rights as well as to Commission members-to the Minerals Convention, but the Advisory Committee has no independent decisionmaking power. The reports of the Advisory Committee must reflect the conclusions reached at its meetings and all views expressed by members of the Committee. While lacking decisionmaking authority, the advice of the Advisory Committee is nevertheless likely to be taken seriously by the Commission and Regulatory Committees, for substantive and political reasons.

There has been some concern that Parties' designated representatives on the Advisory Committee may be subject to pressures to ignore their "technical" role and provide opinions that reflect political decisions taken within their countries. There appears to be no way to prevent this; it can only be guarded against by the ''sunshine' provisions in the regime (open meetings and reports) and by the international and public pressure likely to result from abuse of their technical function.[4]

The Arbitral Tribunal

Parties to disputes arising out of the interpretation or application of the Minerals Convention are encouraged to try to resolve them on their own. When this cannot be accomplished within 12 months, a three-person Arbitral Tribunal may be established or the dispute may be submitted to the International Court of Justice (art. 56(1)), Disputes related to the discretionary powers of the Commission or Regulatory Committees are not subject to the authority of the Arbitral Tribunal, and other limitations to the types of disputes that maybe decided by the Tribunal apply. However, for those disputes submitted to the Tribunal, decisions are intended to be final and binding. Tribunals will consist of one arbitrator from each of the two disputing parties (or group of parties with a similar interest) and a third arbitrator acceptable to both disputants,

The Secretariat

The Commission may establish a Secretariat staff, as necessary, to support the work of the other institutions of the Minerals Convention. Parties to the Convention on the Conservation on Antarctic Marine Living Resources (CCAMLR) found it

[4] L.A. Kimball, ''The Antarctic Minerals Convention, " Special Report, International Institute for Environment and Development-North America, July 1988, p. 29.

necessary to establish a Secretariat to support living resources activities; however, a secretariat has yet to be established to support Antarctic Treaty activities. At issue is whether the establishment of a permanent, central staff will prejudice the juridical positions of countries. Some claimant states, in particular, have been opposed to creating a permanent secretariat for the Antarctic Treaty meetings, preferring instead to continue the current practice of rotating secretariat functions.

Special Meeting of Parties

Like the Advisory Committee, the Special Meeting of Parties is composed of representatives of all Parties to the Convention but has no independent decisionmaking authority. The sole function of this body is to advise the Commission on whether identification of an area for exploration and development is consistent with provisions of the Convention. The Special Meeting of Parties is designed to afford some opportunity for all Parties to participate in the institutions of the Minerals Convention. Although the Special Meeting of Parties lacks any formal power, it maybe difficult for the Commission to ignore an opinion that development in a specific area would be inconsistent with the Convention.

DECISIONMAKING AND COMPROMISE

The decisionmaking systems of the Convention, like most voting systems in international organizations, proceed on the assumption that each state casts one vote.[5] They attempt to accommodate states with more substantial interests by using two basic techniques, often in combination. The first is to confine some or all decisions to organs with small membership, thereby maximizing the affirmative and negative voting power of the small group of members, some of whom may be guaranteed permanent membership. This is true of the Commission and especially of Regulatory Committees. The second is to maximize protection for negative interests by requiring more than a simple majority for some or all decisions, running the gamut from a two-thirds majority to consensus, and possibly including concurrent votes of certain states or groups of states. Under the Convention, the Commission requires three-quarters majority votes or consensus for decisions, while the Regulatory Committees utilize simple two-thirds majorities for less important matters of substance and concurrent two-thirds majorities of its constituent groups (claimants and nonclaimants) for the most important matters.

This system has an unavoidable trade-off. The more a state seeks to enhance its own blocking power, the more it is compelled to grant similar power to at least some other states, thereby making an affirmative decision more difficult.[6] It is possible to convert negative power into affirmative power by insisting on approval of one's affirmative agenda as a condition for allowing approval of someone else's affirmative agenda. The difficulty is that every state or group of states with negative power can do the same thing.

The question of U.S. influence concerns not only the direct voting power of the United States, but the voting power of states likely to share U.S. interests or otherwise inclined to accommodate those interests. Where underlying interests are complex, support can be difficult to predict. Some governments with which the United States has very good bilateral relations attach considerable importance to their relations with Third World leaders or other voting blocs in international organizations. Some major industrial states and U.S. political and military allies are territorial claimants in Antarctica. U.S. interests and theirs might diverge on matters affecting the claims. At least juridically, the Soviet Union's approach to Antarctica is similar to that of the United States, yet its behavior in decisionmaking for a could be influenced by the general state of U.S.-Soviet relations and divergent political, economic, or strategic interests.

The Parties had to balance the interests of claimants, nonclaimants, and other cross-cutting

[5] Weighted voting, in which each state is accorded a different number of votes in accordance with a formula designed to reflect relative interest Or contribution, is used in some commodity arrangements and funding institutions.

[6] The virtues and problems of negative voting power are amply demonstrated by the voting system in the U.N. Security Council. According a veto to each of the five permanent members tends 10 assure adequate support from the major powers for decisions with important international security implications, and seines to protect each of them and their allies from adverse decisions. At the same tune, the veto power can substantially limit the responsiveness of the Council to situations in which affirmative decisions are deemed useful by the United States or others.

interest groups in order to achieve an agreement. The checks and balances embodied in the responsibilities, decisionmaking authority, voting procedures, and composition of each institution try to achieve this political compromise. A certain amount of ''horse-trading' by the claimant and nonclaimant groups and by market and centrally planned counties was necessary in order to obtain a mutually acceptable result.

Some will see the compromises made in the Minerals Convention as going too far and prejudicing the legal positions of either claimant or nonclaimant groups or of surrendering too much to either environmental protection or of development. **The Minerals Convention is the first Antarctic agreement in which any special rights are accorded to the seven claimant States** as claimants. In no other ATS agreement has a claimant been given an express right to a special position by virtue of being a claimant, or been accorded any express right to a special role with respect to the particular area it claims. The Convention explicitly establishes a decisionmaking structure for Regulatory Committees that divides claimants and nonclaimants into separate groups. Moreover, a state with a territorial claim to a particular area has, by virtue of that claim to that particular area:

- a right to serve on a Regulatory Committee established for an area that includes the area it claims (art. 29);
- a right to influence which of the other territorial claimants will sit on that Regulatory Committee (art. 29);
- a right to demand that the Regulatory Committee ''have recourse' to it in considering an application for an exploration permit and the related Management Scheme (art. 46);
- a possible argument that its interests are entitled to special respect in any disposition of surplus revenues from the area it claims (art. 35); and
- a possible argument that it has a duty to take measures in the area it claims to ensure compliance with the Convention (art. 7).

On the other hand, if claimants ratify this Convention, they will forgo ever having exclusive rights to any resources found in their claimed territory (although in return they will gain access to all Antarctic resources and a role in all Commission decisions). While claimant States' expectation of exclusive rights to resources in ''their' areas may have been unrealistic, it might be argued that the Convention is the latest and most serious erosion of claimant ''rights' in Antarctica, beginning with the Antarctic Treaty, and despite treaty language stating that preexisting judicial positions will not be affected by it.

The special interest of the United States and the Soviet Union as states having a basis for a claim in Antarctica is also specifically recognized in the Convention. The United States and Soviet Union must be represented on all Regulatory Committees, and, hence, have been accorded many of the same special rights as claimant states. **Arguments about whether claimants or nonclaimants benefit more from the Convention will probably remain inconclusive.**

Even though some states will have a larger voice in the Regulatory Committees, the general interests of all Antarctic Treaty Consultative Parties are protected by the functions of the Commission. All Parties also may express their concerns in the Advisory Committee and Special Meeting of Parties.

Claimants wanted the Regulatory Committee to have more discretionary powers because they were wary of the nonclaimant majority on the Commission, But many nonclaimants wanted the Commission to be strong and to review Regulatory Committee actions.[7] In the end, the Commission was given power to set parameters for rulemaking by the Regulatory Committees and to review certain Regulatory Committee actions. Hence, neither the claimant nor the sponsoring state within the Regulatory Committee, nor the Committee itself, have blanket discretion. Each is limited by the functions assigned to the Commission and subject to the advice of the Advisory Committee on technical and environmental issues.[8] Although the United States had preferred all decisions to be made by less than unanimous votes, so that no single state would have a veto, U.S. negotiators went along with the consen-

[7] Kimball, op. cit., footnote 4, p. 24.

[8] Ibid., p. 24.

sus rule for the ''trigger' decision on whether to open an area-so long as less than unanimous votes were used in the Regulatory Committees after investments had begun.

Some environmental groups criticize this division of **authority,** which gives Regulatory Committees important independent power. They argue that the Commission should have the ultimate authority to approve or deny all key decisions.[9] Env ironmentalists fear the smaller Regulatory Committees are likely to be composed of states seeking to cut a deal to promote development, and thereby will sacrifice environmental safeguards. Although the Commission may review Regulatory Committee actions, they argue, it will not have the power to overturn decisions that could harm the environment. While a Commission with the authority to overturn Regulatory Committee decisions might be more responsive to environmental concerns, there is no guarantee that it would be. Also, a Regulatory Committee would have difficulty ignoring the Commission's guidelines when developing a Management Scheme, as well as later suggestions made by the Commission, the advice of the Advisory Committee, or the views of individual States with strong environmental concerns.

Finally, since the Commission has the responsibility **to** open areas to exploration and development and to designate members of the Regulatory Committee for each area, it can assure a balance of development and environmentally inclined states in each Regulatory Committee. Given the diversity of interests of the Parties, it is difficult to see how an agreement could have been reached that vested all important power in just one of the institutions.

A FRAMEWORK REGIME—AND UNCERTAINTY

The Minerals Resource Convention has been termed a framework regime. It does not contain a detailed mining code or regulations. Rather it relies on general guidelines and some specific requirements and prohibitions, much as a general statute delegating authority to an administrative agency might do. **The details of many of the elements of the new regime have not yet been specified and will not be specified until it is necessary to do so.** With respect to exploration and development, most of the regulatory system will be put into place for each area of Antarctica when that area is identified (opened) by the Commission for receipt of applications for exploration and development. Some of the conditions and guidelines will be specified by the Commission at the time it identifies the area. The remainder will be determined by the Regulatory Committee established for the particular area, either by general regulation or in the context of the Management Scheme applicable to a particular Operator in a particular block within the larger area for which the particular Regulatory Committee is competent. Even though many details remain to be worked out, the Convention is still elaborate and by far the lengthiest of the ATS agreements.

The flexibility of this system is an advantage to the Parties to the Minerals Convention. Too much detail is probably not desirable now since it is impossible to anticipate all requirements the Convention must meet. On the other hand, the gaps remaining in the regime may be seen by potential Operators as disadvantages.

Some of the regime's lack of detail (and in several cases ambiguity) is seen as a shortcoming by both development-minded and environmental groups.[10] *For example, investors* in resource development generally want to know the ''rules of the game" early so that, before making substantial investments, they can decide if the expected returns are worth the risks. The Convention does not specify what levies Operators will have to pay to support the Convention or the amount of '*payments in the nature of, and similar to taxes, royalties, and payments in kind. " Also unknown are the Operator's specific liabilities. However, much uncertainty should be resolved in a Management Scheme prior to the time an Operator must commit substantial capital to an operation, and uncertainty at the prospecting stage would not be costly.

Security and predictability are also important to investors, especially once a Regulatory Committee approves a Management Scheme and issues an

[9] Antarctic and Southern Ocean Coalition, ' 'Analysis of the ConventIon on the Regulation of Antarctic Mineral Resource Activities, ' ASOC Information Paper 19884 October 1988, p. 6.

[10] See Antarctic and Southern Ocean Coalition, ibid.; also, OTA Workshop on the Antarctic Minerals Coil}'clllon, Dec. 15, 1988.

exploration permit (see below). Can development be stopped even after significant investments in exploration have been made and performance criteria have been met? Article 54, discussed in more detail below, is ambiguous on how this decision would be made.

Similarly, environmental groups are concerned that some aspects of uncertainty and ambiguity in the Convention may work to the disadvantage of environmental protection. For instance, the Minerals Convention requires that information 'adequate' to enable informed judgments be available before major decisions (such as opening an area) can be made (art. 4(1)). Also, no minerals activity is to take place unless it would not cause "significant" adverse effects on air and water quality (art. 4(2a)). Although words such as "significant" and "adequate" are subjective, it would have been difficult to tie the Parties down to more specific terms and still reach agreement. These terms will be defined in more detail by the institutions as necessary.

THE RESOURCE MANAGEMENT PROCESS

The Convention divides resource activity into prospecting, exploration, and development (tables 3-3, 3-4, and 3-6).

Prospecting

Prospecting is the first phase in the resource exploitation process (figure 3-1 and table 3-3). It consists of those methods and techniques that help miners determine targets for more intensive exploration. Successful prospecting may lead to exploration and development if economic conditions warrant and if the environment would not be 'significantly harmed.

The methods used in prospecting are not easily distinguishable from those methods scientists employ in acquiring basic geophysical, geochemical, and geologic knowledge, nor are the results. Also, the geophysical research of some countries in Antarctica is carried out by the same organizations that would conduct prospecting activities. The difference between scientific research and prospecting is largely a matter of intent. The distinction is relevant because the Minerals Convention allows prospecting data to be held as proprietary whereas, under terms of the Antarctic Treaty, the results of scientific research must be made freely available to all.

Exploration and development, as defined in the Minerals Convention, have not yet commenced in Antarctica. This is due in large part to the fact that there is little current interest in such activities. In 1977 the Antarctic Treaty Parties formally agreed to refrain from exploration and exploitation in Antarctica pending progress toward a regime governing these activities.11 But geophysical and other surveys have been conducted as scientific research-though they may produce information of potential commercial value-and thus, have not been subject to the voluntary restraint agreement on exploration. Unfortunately, the data from some past "research' surveys have not been released yet, thus raising speculation about whether these data were collected for research or for commercial purposes. Moreover, there have been varying interpretations of when data should be released.

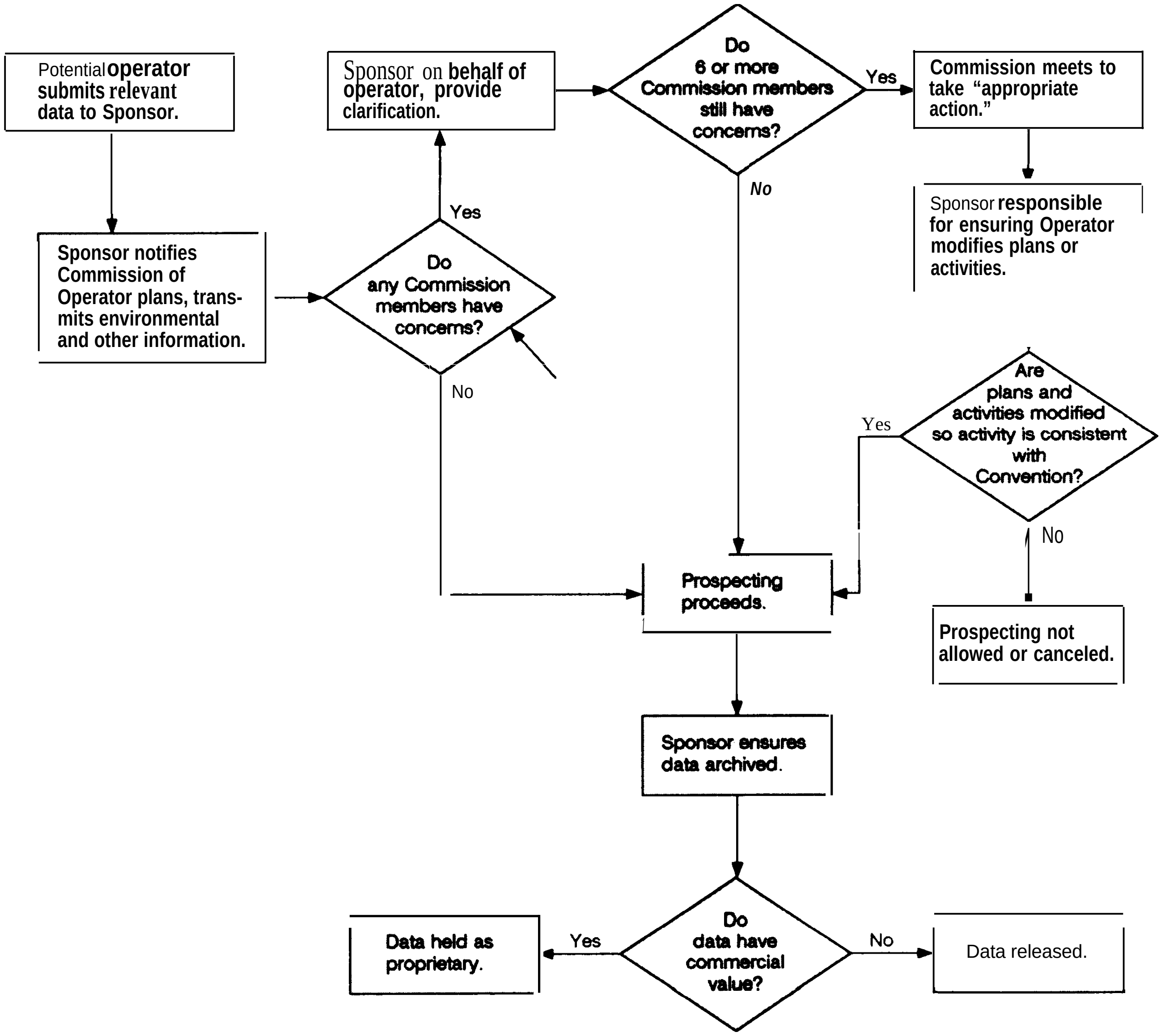
The Minerals Convention clearly distinguishes between prospecting and exploration. The Final Act of the Convention extends the policy of voluntary restraint the Parties adopted in 1977 pending entry into force of the Minerals Convention. The policy now specifically applies to prospecting as well as to exploration and development. Geophysical and other surveys may still be carried out as scientific research, but as research, the results must be made freely available. One result may be that fewer geophysical surveys will be undertaken until the Convention enters into force. Potential prospectors are unlikely to run the risk of engaging in any ''questionable' scientific research that may be viewed as prospecting prior to entry into force of the Minerals Convention, for they could lose their proprietary rights to this data.[12]

Prospecting under the Minerals Convention is subject to much less oversight by the Convention's institutions than exploration and development. It may be undertaken prior to the opening of an area to these activities, Explicit authorization is not re-

I [1]Recommendation IX- 1, 9th ATCM, London, 1977.

[12]Kimball, op. cit., footnoted, p. 4.

Figure 3-l—Prospecting: Articles 37 and 38



SOURCE: Office of Technology Assessment, 1989.

quired because prospecting activities are expected to have no greater impact than similar scientific research. Thus, for 'the most part, prospecting activities are expected to be of short duration and to leave little trace behind. Prospectors are subject to the same general requirements and obligations set forth in the Convention, however, including those meant to safeguard the Antarctic environment. And prospecting may be prohibited or canceled or plans may be altered if Commission members have sufficient concerns about planned or ongoing activities.

Prospectors may hold data they obtain as proprietary for at least 10 years if it has commercial value, but significantly, prospecting confers no special

Table 33-Prospecting

Definition: Activities, including logistic support, aimed at identifying areas of mineral resource potential for possible exploration and development, including geological, geochemical, and geophysical investigations and field observations, the use of remote sensing techniques, and collection of surface, seafloor, and subice samples. Such activities do not include dredging or excavations, except to obtain small-scale samples, or drilling, except shallow drilling not to exceed 25 meters. Art. 1(8).

General provisions:
- Does *not* confer upon any Operator any right to Antarctic mineral resources. Art. 37(1).
- Does *not* require authorization by the institutions of the Convention. Art. 37(2).
- Data of commercial value may be retained, as long as the Sponsoring State certifies that they continue to have commercial value. Art. 37(10).
- Notification of prospecting by Sponsoring State must be accompanied by fees (yet to be established) and by: a) identification of the general area for prospecting, b) identification of the mineral resource(s) under investigation, c) a description of the methods to be used and the general work program, d) an assessment of the possible environmental impacts of the prospecting, e) measures to be used to avoid and/or to mitigate any harmful impacts, and f) proof that the Operator has a substantial and genuine link with the Sponsoring State and is financially and technically qualified to carry out the prospecting. Art. 37(7a-f).

Institutional oversight
- Minimal, but if a Commission member is *concerned* that prospecting is not being conducted in a manner consistent with the Convention or that planned prospecting would not be consistent with it, the member may ask for a clarification. If it is still concerned, in concert with at least five other Commission members, it may call a meeting to take appropriate action. Art. *38.*
- The Commission may adopt additional general measures concerning prospecting applicable to all operators. Arts. 37 and 38.
- As appropriate, the Advisory Committee provides advice to the Commission. Art. 26(2a).

Key sponsor ***obligations:***
- To notify the Commission on behalf of its Operator at least 9 months before planned prospecting, the notification to include the information listed above. (Presumably, in cases where Operators and Sponsors are independent of each other, the Operator will supply this information to the Sponsor, who will in turn certify it and forward it to the Commission.) Art. 37.
- To ensure that Operators are qualified to undertake prospecting in conformance with the Convention, and especially that they have the appropriate financial and technical means to respond to threats to the environment. Art. 37.
- To ensure that Operators have the financial capacity to meet liability standards, Art. 37.
- To ensure that Operators conduct themselves with due regard to the rights of other Operators in the area. Art. 37.
- Where modifications to a proposed prospecting plan or to ongoing prospecting are deemed necessary, to ensure that the plan or activity of the Operator is modified. Art. 38.
- To ensure that response action is taken in the event that the Operator fails to do so. Art. (37(3a)).

Operator obligations
- Maintain the financial and technical means to conduct all activities in compliance with the Convention. Art. 37.
- Maintain a substantial and genuine link with the Sponsoring State. Art. 37.
- Conduct all activities with due regard to other Operators' rights. Art. 37.
- Unless waived, *remove all* installations and equipment after prospecting ceases and rehabilitate the site. Art. 37.

SOURCE: Office of Technology Assessment, 1989.

rights to an area. Exclusive rights to explore and develop an area may be obtained only after the relevant area has been opened, competing applications to explore the same parts of the area have been resolved, and an exploration permit has been issued. It does not appear that this uncertainty will operate as a significant deterrent to the oil and gas industry in prospecting. This industry is generally used to a system under which investments in prospecting will not necessarily entitle them to exclusive rights to explore or exploit in the area in which they conducted prospecting. The mining industry, on the other hand, neither has the financial resources that the oil and gas industry has for prospecting and exploration nor is as used to spending large sums without the certainty that it will acquire rights to its discoveries.

Some prospecting is likely to occur at a relatively early date if the Minerals Convention is ratified and enters into force--even if near-term interest in developing Antarctica's resources remains slight. Companies and nations that take a "long view" about exploiting Antarctica's resources may wish to be in a position to evaluate the economic and technical feasibility of resource exploitation, anticipating that prices will eventually be higher.[13] Prospecting may not lead immediately to exploration and development, however, in part because the economics of development may not warrant proceeding beyond the prospecting phase. For this reason, when the United States considers implementing legislation for the Minerals Convention, it may wish to devote somewhat more effort to developing regulations applicable to domestic pros-

[13] Ibid., p. 4.

pectors. There is likely to be additional time in which to formulate domestic implementing legislation for exploration and development of Antarctica's resources,

Identification of an Area for Exploration and Development

One of the most important decisions specified by the Convention is how an area of Antarctica is opened for exploration and development. If a prospector determined that there was sufficient incentive to proceed with intensive exploration of a particular site, the prospector would request that its Sponsor ask the Commission to identify (open) the area in question (figure 3-2). The Commission's **decision to open an area must be made by consensus.** This is the decision that triggers the formation of a Regulatory Committee, consideration of exploration and development permits, development of a Management Scheme, and, in general, greatly increased activity. The Commission must decide whether identifying all or part of the area is consistent with Convention standards, and, in theory, Commission members will base their vote on all relevant information submitted by the requesting Party, other interested Parties, the Advisory Committee, and the Special Meeting of [All] Parties.

To the extent that the United States is reluctant for any reason, such as environmental concerns, to allow an area of Antarctica to be opened to exploration, the consensus voting requirement ensures that opening the area can be blocked. However, if the United States wants an area opened, any other member of the Commission could block its request. Since some state member might oppose opening an area on environmental or other grounds or seek to impose conditions which effectively do the same thing, the U.S. interest might be thwarted. An environmental group's opposition, if based on plausible evidence, might serve as the pretext for a state's negative vote.

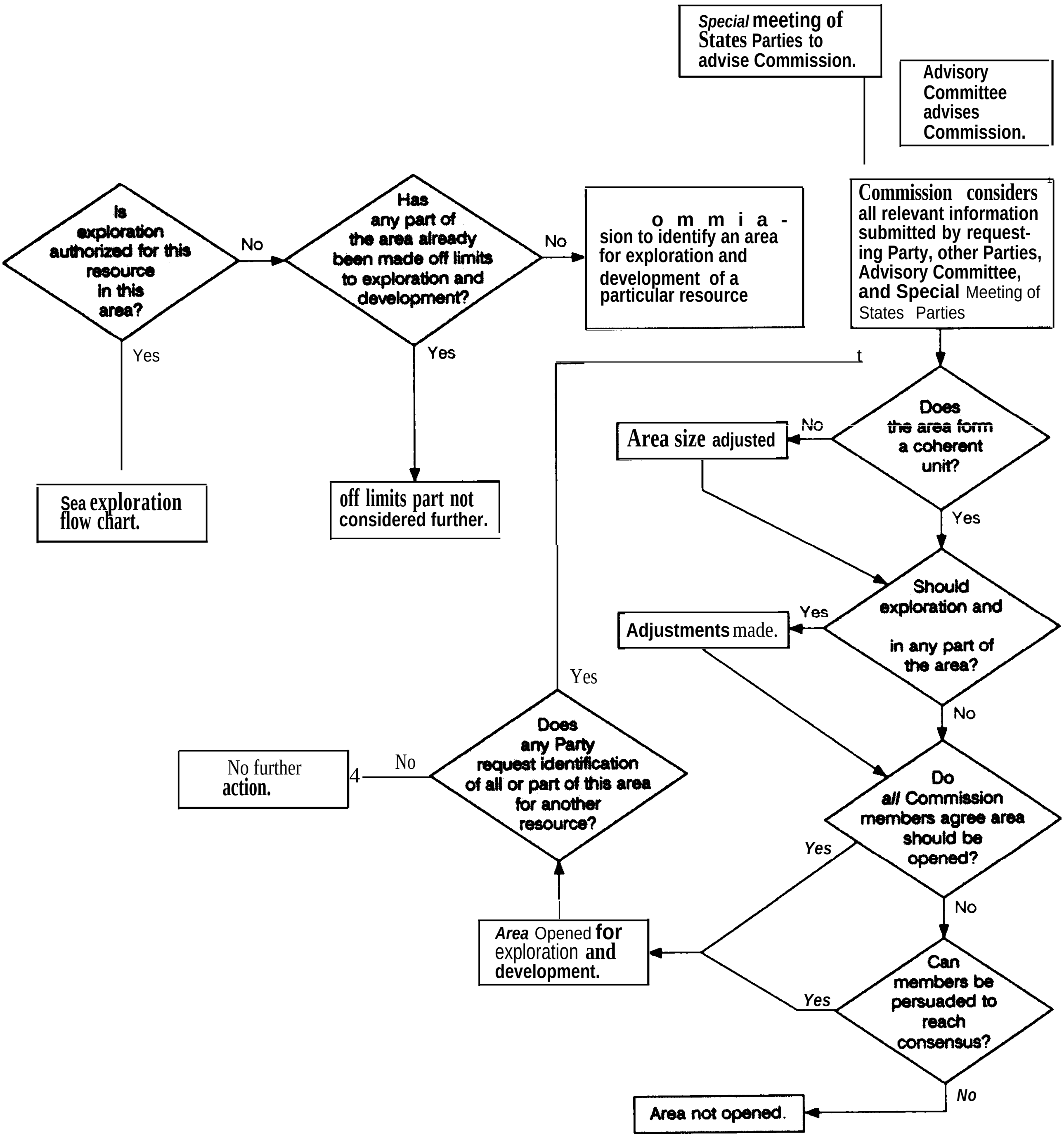
It is not clear what financial, temporal, or other disincentives to proceeding with exploration might deter a state or company from seeking to have an area opened to exploration applications relatively early. While OTA predicts that actual development is unlikely absent a very valuable find and extremely favorable projected market conditions, it is less clear how far in advance a serious effort would be made to ''trigger' the system by seeking to open an area. One of the biggest deterrents to opening an area is likely to be the need for adequate information, One incentive for early application to open areas to exploration and development is the provision that prospecting data must be made public after 10 years, although there are also provisions to extend the 10-year protection of such data (art. 37).

It is likely that the more important an area is likely to be to consumers, the greater will be the pressure on the Commission members to approve a request to open it. The ''nightmare' scenario of a Western country, in desperate need of oil, being frustrated by Commission vetoes is improbable. If the situation were that critical to the West, a threat to denounce the Convention would presumably be real. In that case the possible collapse of the Convention (and likely the entire Antarctic Treaty System along with it) would be viewed by all Parties with alarm.

The Commission includes some oil exporting states (e.g., the United Kingdom and Norway). None has thus far associated itself with a cartel, However, it is possible the consensus requirement could inspire a member of OPEC (the Organization of Petroleum Exporting Countries) to invest in the Antarctic research necessary to join the Commission, so as to gain a veto over the decision to open Antarctica to oil exploration and development. However, an economically motivated move by an oil exporter to restrain Antarctic production would likely unite the existing group of states active in Antarctica, in part because most are consumers and in part because they perceived that their system was being manipulated for outside ends. In such an atmosphere, it is not likely that the attempt to block consensus would long survive. The same argument is likely to be true for hard minerals exporters.

Would the presence of the Soviet Union on the Commission likely be a problem for the United States? The Soviet Union is certainly capable of using its veto for purely political ends. Whether, in particular circumstances, it would do so is another matter. If the question arose at a time when the Soviet Union was seeking better relations with the West or more Western capital and investment, the chances of a veto are reduced. If the question arose at a time of high tension, the Soviet Union would

Figure 3-2-Opening an Area: Articlea 3941



SOURCE: Office of Technology Assessment, 1989.

nevertheless have to consider its interests in maintaining the stability of the Antarctic system and its interests as a consumer of the commodity concerned. The Soviets would also have to consider whether they have an interest in developing Antarctic mineral resources themselves. If that country considers undertaking mineral development, it might be deterred from vetoing a U.S. request so as not to trigger a U.S. veto of its own request.

While these scenarios are unsettling, they are not very likely. Two other scenarios are likely to be of more concern: 1) when there is genuine disagreement about the environmental hazards of opening an area, and 2) when other states demand to participate in a proposed minerals activity, whether the United States or some other state sponsors the activity.

Genuine Disagreement Over Environmental Hazards—This situation may be less unsettling for the United States because U.S. interests include an interest in protecting the environment, because the United States is already among the more environmentally concerned Commission members, and because U.S. companies have substantial experience in working with environmental constraints and bearing their added costs. Any proposed development that is likely to survive our domestic political process is unlikely to attract strong and genuine foreign opposition on environmental grounds. This is particularly true since U.S. environmental procedures and standards are likely to apply to any decision by the U.S. Government to propose the opening of an area or to sponsor an applicant. At the same time, any environmental organizations that actively oppose opening an area can be expected to focus lobbying efforts on those countries most likely to cast a dissenting vote,

Demands for Participate---Intemational participation, especially by developing country Parties, is encouraged by the Convention (art. 6). Demands for participation could come from a variety of sources and for political or economic reasons. A territorial claimant, for instance, might demand to participate in a venture in order to establish the principle that exploitation in ''its' area requires its participation, thereby guaranteeing *de facto* accommodation of its claims. Alternatively, developing countries might demand to participate for ideological reasons (one could find the economic interests of a state or of private companies in one or more proto-industrial states behind the ideological rhetoric),

A foreign state's demand to participate may increase the cost of the venture to the Operator. On the other hand, development of Antarctic resources is likely to be so expensive that investors will most likely spread the risk by forming joint ventures (app. A presents a scenario of how a joint venture might work).

The Convention limits the role of the Commission ''to 'elaborating opportunities' for joint ventures or different forms of participation' (art.41 (Id)). There is also helpful interpretive language in the Final Act concerning the ''freedom of choice' of an investor regarding partners in a joint venture, including terms of their partnership. Nevertheless, there will be ample opportunity for bargaining. Potential investors will have to consider that even if a veto in the Commission can be avoided, both the Soviet Union and a territorial claimant over the area in question will wind up on the relevant Regulatory Committee, and would thus be in a position to influence future decisions if their interests are not accommodated.

It is also possible that one or more Commission members will demand a price for their cooperation in supporting a decision to open an area. Such price may be unrelated to the Antarctic minerals regime, in which firm diplomacy may contain Antarctic bargaining to Antarctic issues. However, if the price of support is relevant to the Antarctic minerals regime or other Antarctic diplomacy, then ''logrolling, a time-honored characteristic of collective decisionmaking bodies, is likely.

The Convention's provisions for opening an area for exploration and development:

- guarantees that no area will be opened over the objections of the United States;
- comes close to guaranteeing that no area will be opened for development over well-founded environmental objections;
- does not assure that any area of Antarctica will be opened; and
- subjects states that seek to open an area to a variety of demands that may have to be accommodated to open the area.

The consensus requirement supplies a great deal of protection for U.S. environmental and scientific interests, but little protection for potential U.S. economic interests. It protects U.S. interests in stability in Antarctica by guaranteeing the consent of all substantially interested states before exploration and development is undertaken. If, however, significant concessions to territorial claimants are made as the price of a decision to open an area, the consensus requirement may prejudice the long-term stability of the current Antarctic system, and long-term U.S. political, legal, economic, and environmental interests.

From the point of view of the petroleum and mining industries, the number of sovereign states involved in the decisionmaking process, as exemplified by the requirement for a consensus decision to open an area, is worrisome. United States international oil companies are accustomed to, and adept at, negotiating with all sorts of governments on an individual basis. But to have to satisfy a large group of countries, each with somewhat different interests, is daunting, even if the Sponsor is the more directly involved party in the process.[14] Private companies, whether domestic or foreign, might indeed prefer dealing with a single sovereign power in Antarctica if such an option were possible.

Exploration

Once an area has been opened for exploration and development, Operators may seek approval for exploration (figure 3-3 and table 3-4).

Application Procedures

The Regulatory Committee must initially establish procedures for receipt of applications for exploration or development permits. Subject to any decisions by the Commission regarding maximum block size and application fees, the Regulatory Committee will then divide the area into blocks and set the relevant application fees.

The Regulatory Committee will also establish procedures for resolving competing applications for the same block where the applicants have not resolved the matter themselves. Those procedures must include priority for the application with the broadest participation among interested Parties, including developing countries in particular.

These decisions require a two-thirds majority of the states present and voting, that is 7 out of the normal 10 votes. (States that abstain are normally not considered to be 'voting.' Four negative votes would be necessary to block a decision if there were no abstentions or only one abstention. If there were two to four abstentions, three votes would be sufficient to block (table 3-5).

To the extent that an issue arises that relates to a difference in principle with the territorial claimants, four claimants, if united, will be able to block any decision favored by six nonclaimants.

To the extent that an issue arises that relates to the general interests of Western consumer nations, the United States should not normally find it too difficult to find three additional negative votes (or two additional negative votes and two abstentions) to block adverse decisions. The four territorial claimants on the Committee will come from among the following group of seven: Argentina, Australia, Chile, France, Norway, New Zealand, and the United Kingdom. At least two of the four might normally be expected to share many of the same interests as the United States, or at least favor accommodation of substantial United States concerns. In that case, the United States would need to persuade only one of the five other nonclaimants of its point of view. It is probable that the nonclaimant group will include at least one additional Western state, for example an European Economic Communit y member or Japan, particularly if the four claimants include only two Western states.

The Regulatory Committee can, if it wishes, establish a limit on the number of blocks that may be accorded to any given Party (art. 43(2)). A block size limitation could pose a problem for Operators, who desire as much assurance as possible that the area in which they are granted exclusive rights will be large enough to contain the size deposits necessary for economic development. If individual blocks are large enough in the first place, the potential problem can be avoided. Moreover, given the multinational nature of the oil and mining industries, and their

[14] J.N. Garrett, "The Antarctic Minerals Regime: A Petroleum Industry perspective," OTA contractor report, November 1988.

capacity to establish subsidiaries with substantial and genuine links to foreign states, the extent to which the risk of an adverse decision on this point should give rise to serious underlying economic concerns is unclear.

Guidelines

The Regulatory Committee is required to adopt guidelines identifying the general requirements for exploration and development in the area of its competence. These will cover the detailed items normally associated with mining regulations.

The adoption of such guidelines requires, in addition to a two-thirds majority, the votes of half the claimants and half the nonclaimants present and voting. Blocking power is thereby increased. A territorial claimant, including the state with a territorial claim in the area in question, would need to persuade only two other claimants of its point of view in order to block a decision, even if there are no abstentions. Under this formula, the United States or another nonclaimant would need to persuade at least three other states to vote ‘‘no’ in order to block a decision in the absence of abstentions.

An impact of this formula is to increase the power of the claimants in general, and of the claimants making claims within the area in question in particular. It could therefore strengthen their ability to extract practical or legal concessions to the territorial claims. An extreme but unlikely example would be a demand that the guidelines conform in significant respects to the mining laws of the state that claims sovereignty in the area.

The Application for an Exploration Permit

Subsequent to the preparatory work undertaken by the Regulatory Committee, the Sponsoring State, on behalf of the Operator, may submit an application for an exploration permit. The application must be accompanied by the fees established by the Regulatory Committee and, according to article 44, contain:

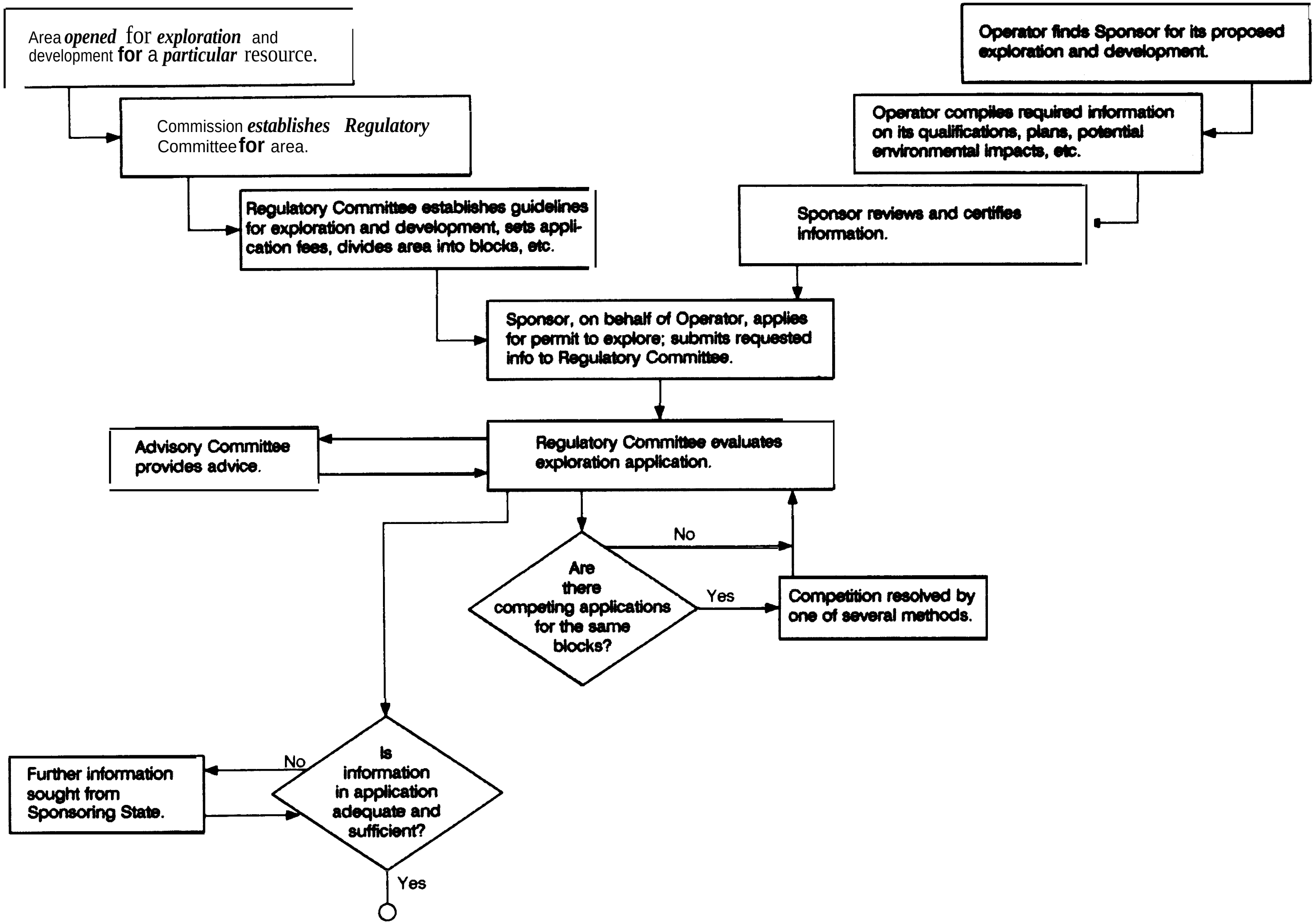
- A detailed description of the Operator, its structure, financial composition, and resources and technical expertise. If the Operator consists of a group of countries, i.e., a joint venture, the application must include a detailed description of the degree (including equity composition) to which the parties are involved in the venture.
- A detailed description of the proposed exploration activities and, to the extent possible, a detailed description of the proposed development plan.
- A detailed assessment of environmental and other impacts of the proposed activities, and a description of the Operator’s capacity to respond to accidents, especially those with potential environmental effects.
- Certification by the Sponsor of the capacity of the Operator to comply with the guidelines established by the Regulatory Committee; of the technical competence and financial capacity of the Operator; and that the relationship of the Operator to the Sponsor is substantial and genuine.
- A description of any proposed joint venture or other participation terms.

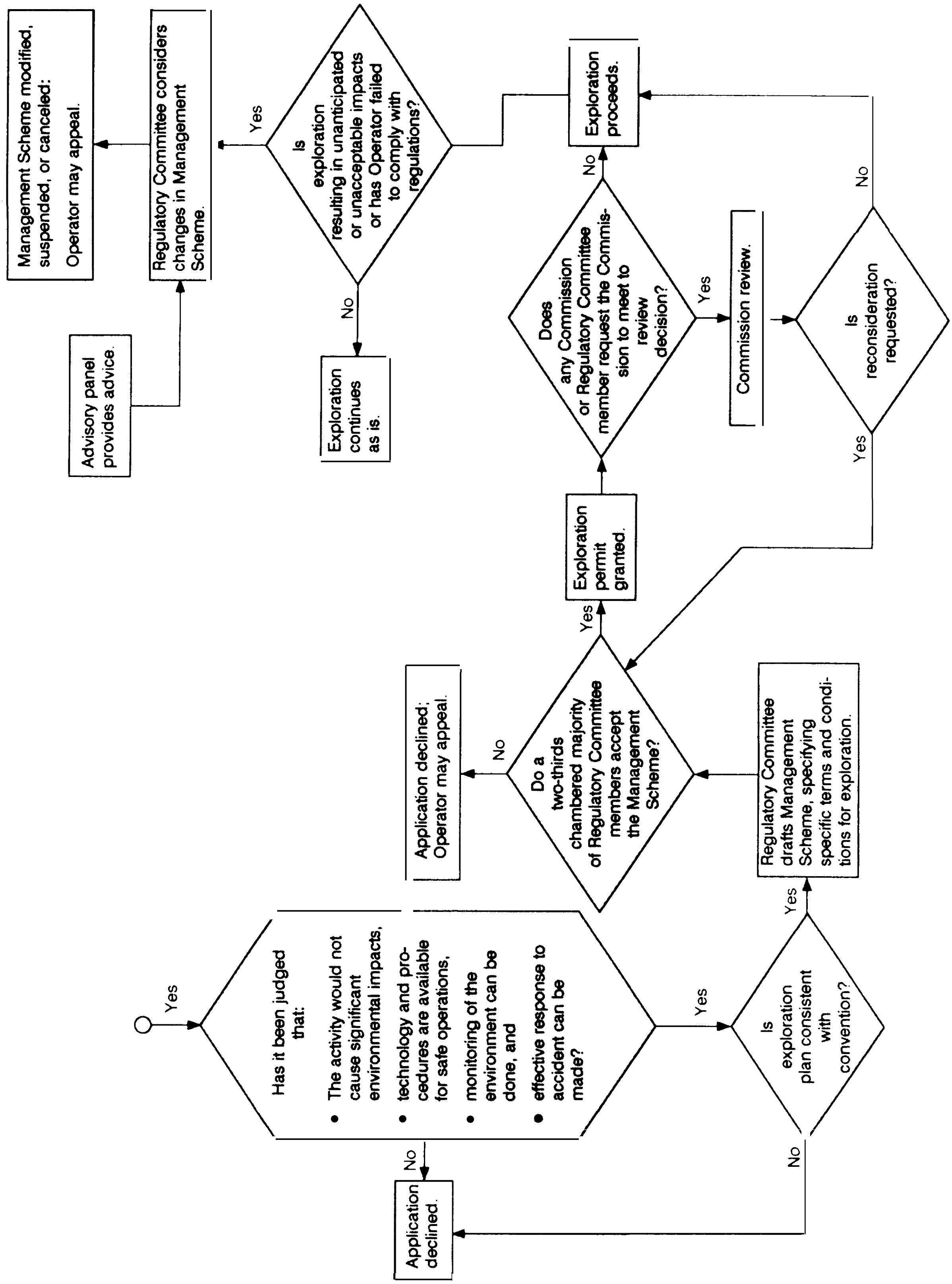
Approval of Exploration Permit and Management Scheme

The Regulatory Committee has the authority to approve an exploration permit and Management Scheme (contract). The approval of an exploration permit and Management Scheme for a specific block accords an Operator exclusive rights to explore for the resources identified and the exclusive right to develop those resources, subject to subsequent issuance of a development permit. The Management Scheme sets out the specific terms and conditions for both exploration and development. Those governing development will only be as detailed as the information available at this stage and are subject to review at the development stage. Terms and conditions must be consistent with the Convention and applicable regulations and guidelines adopted either by the Commission or the Regulatory Committee, and would include procedures for settlement of disputes between the Operator and the Regulatory Committee.

When considering the application and Management Scheme, the Regulatory Committee is required to “have recourse’ to certain of its members: the Sponsoring State, any state making claims in the area with respect to which the Regulatory Committee is competent, and, as may be required, one or two additional members of the Committee (art. 46). The meaning of this requirement is not specified. A procedural right to be deeply involved in the process,

Figure 34-Exploration: Articles 4 and 43-51





SOURCE: Office of Tec og Assessment, 989

Table 3-4-Exploration

Definition: Activities, including logistic support, aimed at evaluating specific mineral occurrences or deposits, including exploratory drilling, dredging, and other surface or subsurface excavations required to determine the nature and size of mineral resource deposits and the feasibility of their development, but excluding pilot projects or commercial production. Art. 1(9).

General provisions:
- Exploration prohibited unless specifically authorized. Art. 4.
- The decision to authorize exploration and possible development in a particular area must be based on information adequate to enable informed judgments, including a description of the physical and environmental characteristics of the area, an environmental impact assessment, and likely scale of development, methods used, and types of resources sought. Arts. 4 and 47.
- Any authorized activities subject to the specific terms and conditions prescribed by Regulatory Committees in Management Schemes. Art. 47.
- An exploration permit accords exclusive rights to the Operator—***subject*** *to consideration of needs for modifications to the Management Scheme prior to development-to* explore *and to develop* mineral resources in accordance with the Management Scheme. Arts. 48, 53, and 54.
- Management Schemes subject to modification if new information suggests greater than anticipated impacts or if an Operator has failed to comply with the Convention. Art. 51.

Institutional oversight
- A consensus decision must be made by the Commission members to allow exploration and development in a particular area. Art. 41.
- The Special Meeting of Parties advises the Commission on whether allowing exploration in an area is consistent with the principles of the Convention. Art. 41.
- The Advisory Committee reviews information submitted to the Commission and Regulatory Committee and gives advice. Arts. 40,45, ***51,*** and ***52.***
- If exploration and development are considered to be consistent with the Convention, a Regulatory Committee is constituted for the area. The Committee is responsible for subdividing the area into blocks, adopting procedures for handling applications, and adopting general guidelines for exploration and development in the area. Arts. 29 and 43.
- The Regulatory Committee examines each application, issues an exploration permit or denies exploration, and devises Management Schemes which prescribe specific terms and conditions under which exploration and development may proceed. Arts. 45-48.
- The Regulatory Committee may suspend, cancel, or modify a Management Scheme if unanticipated unacceptable impacts could result or if the Operator has failed to comply with the Convention. Art. 51.
- Any member of the Regulatory Committee or any six members of the Commission may request a review by the Commission of the Regulatory Committee's decision to approve a Management Scheme or issue a development permit, and the Commission may request that the Regulatory Committee *reconsider its* decision. Art. 49,

Key sponsor obligations:
- On behalf of an Operator, to submit an application for an exploration permit. The application must be accompanied by appropriate fees and by detailed information about the Operator and about proposed exploration activities, including a detailed assessment of environmental and other impacts of the proposed development. (Most likely, the Operator will supply much of this information to the Sponsor. Sponsors will need to establish domestic procedures for accepting and reviewing this information.) Art. 44.
- To certify the capacity of the Operator to conform to the standards of the Convention and to certify the Operator's technical competence and financial capacity, Art. 44(c-d).

Operator obligations:
- 'In concert with the Sponsor, to provide the data and information required for the Commission to consider identifying an area for exploration and development and for the Regulatory Committee to consider issuing an exploration permit. Arts. 39 and 44.
- Exercise its rights with due regard to the rights of other Operators. Art. 50.
- To live up to the specific terms and conditions of the Management Scheme, which relate, inter alia, to duration of exploration, measures and procedures for protection of the environment, response action to environmental mishaps, performance requirements, technical and safety specifications, monitoring and inspection, liability, resource conservation, financial obligations, provision of data and information, and removal of installations and equipment at the end of exploration and/or development. Art. 47. Suspension, modification, or cancellation of a Management Scheme may occur if an Operator fails to comply with the Management Scheme. Art. 51.
- Subject to procedures to be established by the Commission, Operators may request the Arbitral Tribunal andl/or other body to review a denial of an exploration or development permit, cancellation of a Management Scheme, etc. Art. 59.

SOURCE: Office of Technology Assessment, 1989.

rather than any decisionmaking power as such, is suggested. The provision may imply a core negotiating or drafting group, or some less structured form of consultation. The reference to ''one or two' additional members may imply that the United States and the Soviet Union are to be included in all cases, although there appears to be no formal decision in the Convention or Final Act to this effect.

The approval of a Management Scheme by the Regulatory Committee constitutes authorization for the issuance without delay of an exploration permit. The decision to approve the Management Scheme requires a two-thirds vote of the Regulatory Committee, including a majority of the votes of claimants and a majority of the votes of nonclaimants. Absent abstentions, this means that either two claimants or three nonclaimants could block the decision (table 3-5).

This formula increases the ability of the United States to block an adverse decision. Absent ab-

Table 3-&Blocking Power on a Regulatory Committee

A. Votes Requiring a 2/3 Majority

Present and voting	Absent or abstention	Negative votes to block
10	0	4
9	1	4
8	2	3
7	3	3
6	4	3
5	5	2
4	6	2
3	7	2
2	8	1

B. Additional Blocking Options Where 2/3 Vote Must Include Half the Claimants and Half the Non-Claimants

Claimants present and voting	Claimants absent or abstention	Claimants negative votes to block
4	0	3
3	1	2
2	2	2
1	3	1
Non-Claimants present and voting	**Non-Claimants absent or abstention**	**Non-Claimants negative votes to block**
5	1	3
3	3	2
2	4	2
1	5	1

C. Additional Blocking Options Where 2/3 Vote Must Include Majority of Claimants and Majority of Non-Claimants

Claimants present and voting	Claimants absent or abstention	Claimants negative votes to block
4	0	2
3	1	2
2	2	1
1	3	1
Non-Claimants present and voting	**Non-Claimants absent or abstention**	**Non-Claimants negative votes to block**
6	0	3
5	1	3
4	2	2
3	3	2
2	4	1
1	5	1

SOURCE: B.H. Oxman, “Evaluating the Antarctic Minerals Convention: The Decision-Making System,” OTA contractor report, Jan. 9, 19S9.

stentions, the United States would need to persuade either two other nonclaimants, or two claimants, to vote ‘‘no. It also increases the difficulty of achieving affirmative decisions because only two claimants would be needed to block the decision. On the other hand, since the Management Scheme fashioned by the Regulatory Committee or a subset thereof must be consistent with guidelines adopted by the Regulatory Committee, many if not most potential objections may already have been re-Solved.

Development

The holder of an exploration permit pursuant to an approved Management Scheme may apply to the Regulatory Committee at any time through its Sponsor for a development permit for the block and resources covered. The application must be accompanied by the established fees, and, among the several requirements, must contain an updated description of planned development activities, a detailed assessment of the environmental impacts of

Photo credit: Ann Hawthorne

Victoria Valley, Dry Valley area near McMurdo.

the planned development, and a recertification by the Sponsor of the technical competence and financial capacity of the Operator to undertake the planned development (table 3-6).

In considering an application for a development permit, the Regulatory Committee must determine whether modifications are necessary in the Management Scheme. The Convention sets forth only two reasons for such modifications:

1. if the application reveals modifications by the Operator to the development planned in the original Management Scheme, and
2. if as a result either of changes in the planned development or in light of increased knowledge, the development would cause impacts on the environment that were previously unforeseen.

The process for obtaining a development permit (figure 3-4) is described in article 54. Paragraph 5 of article 54 has drawn special attention from potential investors and environmentalists alike due to its ambiguity. At issue is whether a specific vote is required to block development if there has been no agreement on modifications to the Management Scheme.

The paragraph provides that ‘‘if the Regulatory Committee in accordance with Article 32 approves modifications [to the Management Scheme], or if it does not consider that such modifications are necessary, the Regulatory Committee shall issue without delay a development permit. Article 32, paragraph 1, of the Convention provides that deci-

Table 3-6-Developrnent

Definition: Activities, including logistic support, which take place following exploration and are aimed at or associated with exploitation of specific mineral resource deposits, including pilot projects, processing, storage, and transport activities. Art. 1(1 O).

General provisions:

- A development permit is required. Art. 53.
- Additional data-updating that required for exploration—must accompany the permit, including an updated description of planned development, any modifications requested to the approved Management Scheme, and a detailed assessment of environmental and other impacts of the planned development. Art. 53.
- If exploration is authorized and a Management Scheme is in force, an Operator may develop deposits it finds, subject to modifications which may be required to the Management Scheme in light of changes to the planned development or previously unforeseen impacts on the environment. Art. 54.

Institutional oversight

- Regulatory Committee must approve the development plan. Art. 54.
- Under certain circumstances, the Commission may review the Regulatory Committees' decision to approve an application for development and may request that the Committee reconsider its decision. Art. 49.
- The views of the Advisory Committee to be considered. Art. 54.

Key Sponsor obligations:

- At any time during the period in which an approved Management Scheme and exploration permit are in force, the Sponsor may submit an application for a development permit to the Regulatory Committee on behalf of the Operator it sponsors. Art. 53(1).
- Sponsor must recertify the Operator it sponsors regarding technical competence, financial capacity, ability to comply with general requirements related to exploration and development, and maintenance of the link with the Sponsor. Art. 53.

Operator obligations:

- To provide its Sponsor with: a) an updated description of planned development, specifically noting any proposed changes, b) the information required to assess the environmental and other impacts of planned development, and c) the information required for recertification of technical competence, financial capacity, and capacity to comply with the general guidelines for exploration and development in the area.
- To live up to the specific terms and conditions of the Management Scheme, including changes made in the Management Scheme by the Regulatory Committee.
- To maintain a substantial and genuine link with its Sponsoring State.

SOURCE: **Office of Technology Assessment, 19S9.**

sions by a Regulatory Committee "pursuant to' article 54(5) shall be taken by a two-thirds majority vote, including a majority of the votes of claimants and a majority of the votes of nonclaimants This is the same majority required for original approval of the Management Scheme, Absent abstentions, either two claimants or three nonclaimants could block the decision.

The approval of modifications to the Management Scheme would be a decision "pursuant to" article 54(5) requiring the concurrent majorities specified in article 32, paragraph 1. It would be relatively easy to block such a decision (table 3-5). It is clear that once modifications are approved, the development permit must be issued. However, states might seek to block modifications either because they opposed them or because they favored a package of more extensive modifications.

What happens if the requisite majority does not vote in favor of any modifications to the Management Scheme? If there is not enough support for modifications (i.e., if the concurrent majorities necessary for modifications cannot be obtained), does this mean that the development permit is automatically issued without delay? Is an additional affirmative vote required that modifications are not necessary? Is there a point when the negotiating process over modifications is deemed completed and no further negotiation permitted?

Potential investors are concerned about the ambiguity of this article because they are opposed to the separation of the exploration and development stages.[15] They would prefer an interpretation of article 54(5) that does not require reapproval. Investors argue that exploration in Antarctica will be too costly to undertake unless they are certain that they will be able to proceed from exploration to development. Another vote could derail planned development activities after substantial investments have been made. They also note that the initial exploration permit must discuss proposed development activities in as much detail as possible, the Regulatory Committee will already have a fairly good idea of what impacts to expect from development.

Some environmental groups, on the other hand, argue that there must be the possibility of a negative decision at the development stage.[16] These groups point out that development could have a much greater impact on the environment than exploration, Therefore, the Regulatory Committee and the Commission should have the authority to deny a full-scale commercial development permit, They therefore prefer that article 54(5) is interpreted to mean that an affirmative decision to issue or to decline to issue a development permit is intended and also that if an affirmative decision to approve modifications cannot be reached, this does not mean that the development permit is automatically approved or that modifications are not necessary.

Supporters of the argument that article 54(5) is intended as a modification procedure rather than a reapproval procedure can argue that while it is true that investors run the risk that a two-thirds majority might alter the Management Scheme for stated environmental reasons under article 5 l—which refers to general circumstances under which a Management Scheme may be suspended, modified, or canceled-that is far less onerous than running the risk that two or three states, by blocking the issuance of a development permit, could render the investment in exploration useless. Their position would be that the stringent requirements for consensus in the Commission to open an area, and for concurrent majorities in the Regulatory Committee to approve the Management Scheme, represent the appropriate time for according a minority the power to block economic activity, namely before substantial investments have been made.

In this connection they might also note that even where a two-thirds majority modifies a Management Scheme under article 51, the text contemplates the possibility of compensation to the investor (art. 51(6)). No such provision appears in article 54. It would be anomalous to argue that a small minority is empowered to impair investments without compensation, while a two-thirds majority is not.

The potential disagreements posed by the ambiguity in article 54 may not be as great as they appear. It is reasonably clear that the only relevant issue under article 54 relates to previ-

[15] Ibid., p. 31.

[16] Antarctic and Southern Ocean Coalition, op.cit., footnote 9, p. 5

Figure -Development: Articles 53 and 54

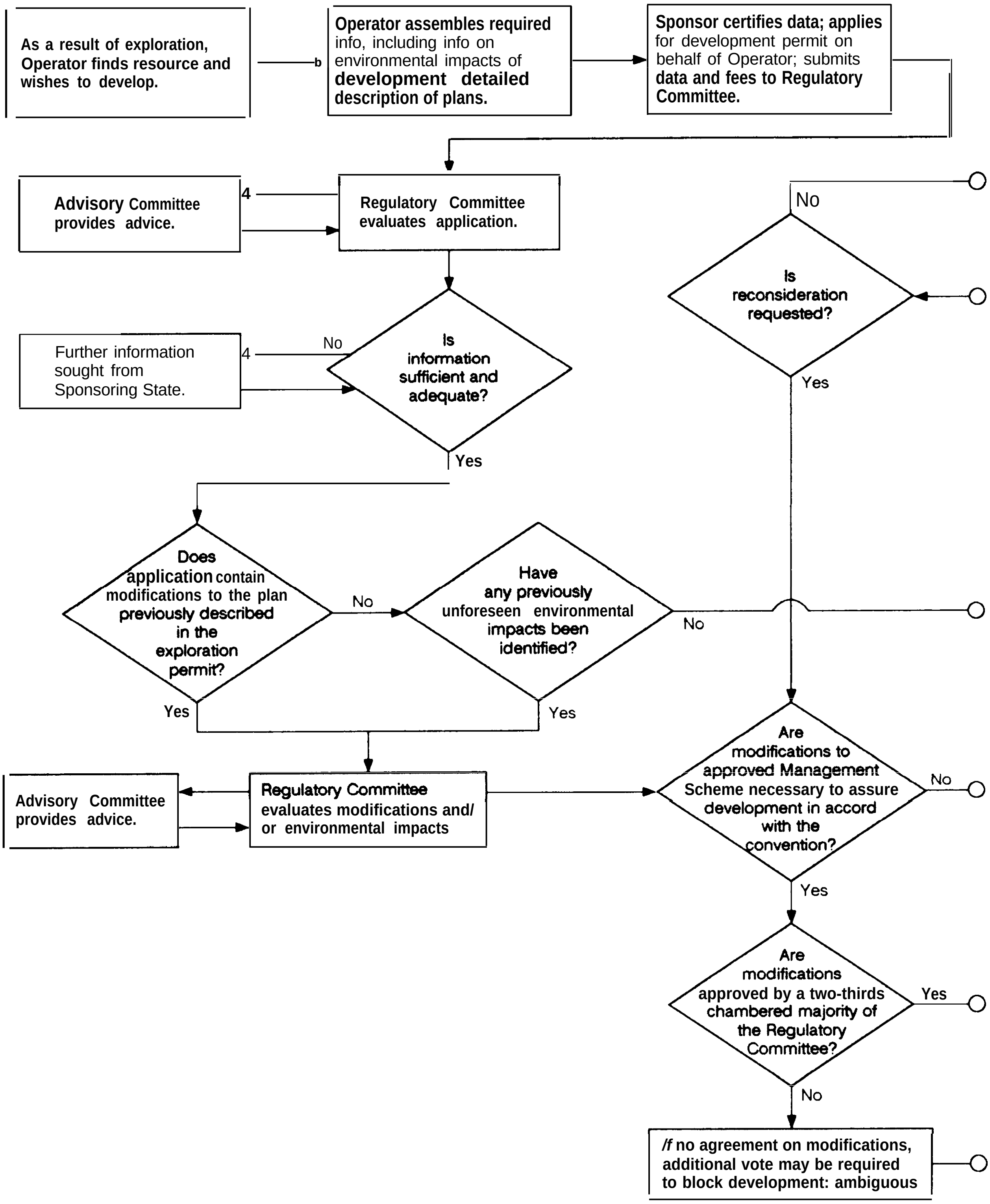
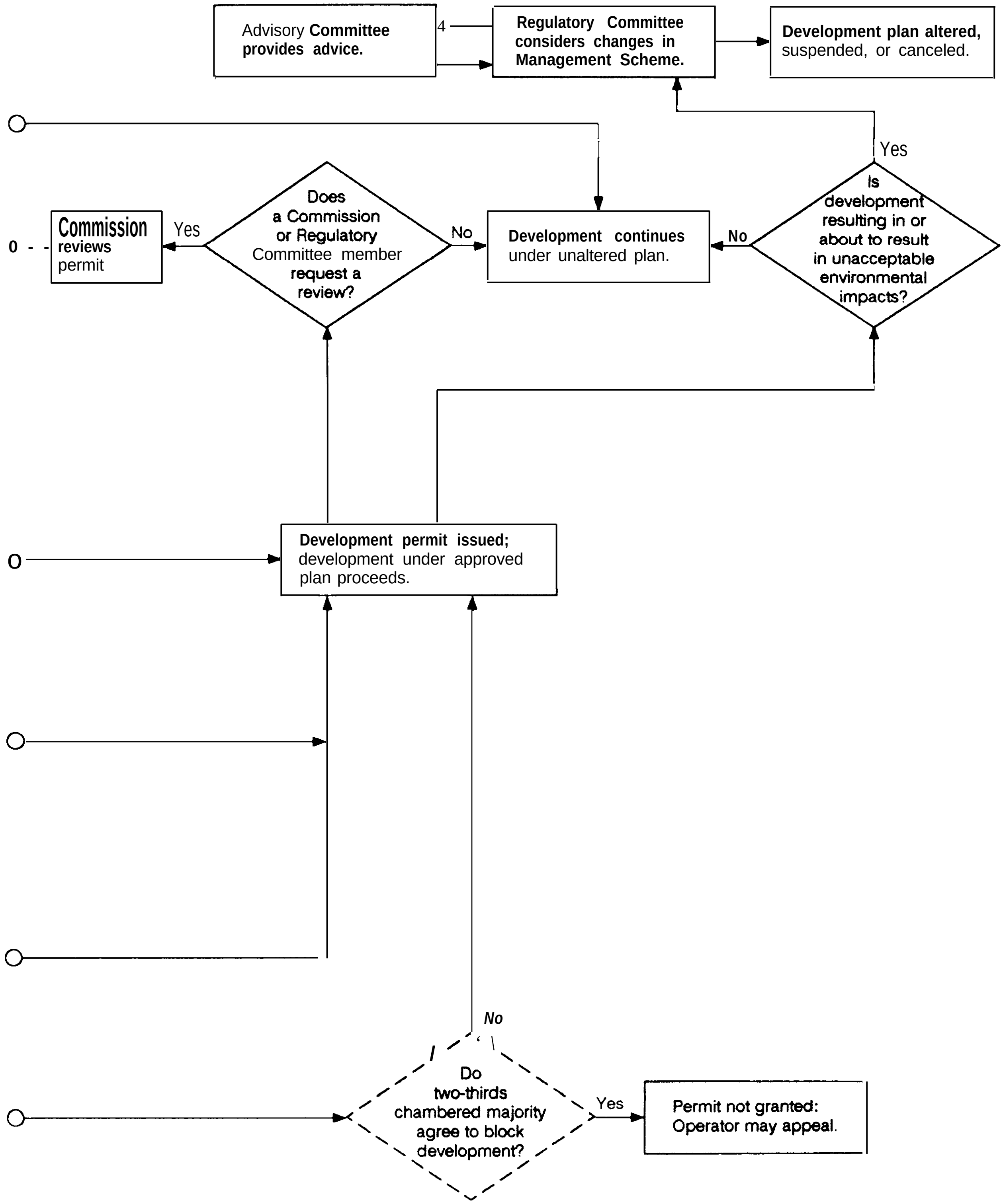


Figure 34-Development: Articles 53 and 54-Continued



SOURCE Office of Technology Assessment 1989

ously unforeseen impacts on the environment, either as a result of modifications to the planned development previously envisioned or in light of increased knowledge. Politically difficult issues, such as participation, will already have been settled at the time the Management Scheme was originally approved. Thus, it does not seem very likely that potential problems will involve more than an accommodation of new environmental concerns. From this perspective, the investor may be better off resolving new environmental problems before proceeding with additional significant investments associated with actual development. The alternative, should the environmental critics turn out to be correct in predicting new environmental risks, could be a far more costly suspension of operations or modification of a management scheme under article **51** at a later stage.

Given the fact that article 54 is not a model of clarity, and that differing interpretations may be proffered not only by different states but by different groups in the United States, it might be prudent to attach a specific statement of interpretation on this point, approved by the Senate, to any instrument of ratification. Such a statement is, however, no guarantee that other states or, if the matter is brought to arbitration, a tribunal, will agree.

SUSPENSION, MODIFICATION, CANCELLATION, AND PENALTIES

Regulatory Committees have the power to suspend, modify, or cancel a Management Scheme as a result of impacts on the environment beyond those judged acceptable at the time relevant decisions regarding the opening of the area and the Management Scheme were taken. Committees can also take such action, or to impose a monetary penalty, in the event an Operator (miner) violates the Convention, measures adopted under the Convention, or the Management Scheme. The response must be proportional to the seriousness of the violation.

The power of the Regulatory Committees is subject to general measures previously adopted by the Commission. Those measures could include provision for compensation to the miner, presumably for certain losses incurred as a result of action taken by a Regulatory Committee. The power of the Regulatory Committees in these respects will also be subject to arbitration. If the Arbitral Tribunal finds that a Regulatory Committee acted unlawfully, it would presumably have the authority to award damages to the Operator, determine that the Committee may not take the action contemplated, or both (art. 59).

Decisions of the Regulatory Committee on these matters require a two-thirds vote. There is no requirement of concurrent majorities. Thus, without abstentions, the United States or any other Party would have to obtain three other negative votes to block a decision. Given the availability of arbitration, the size and likely composition of the Regulatory Committees, and the possibility that the Commission's general measures will add protections for the investor, it is unlikely that Regulatory Committees will arbitrarily y or unreasonably exercise their power.

BUDGET AND REVENUE CONSIDERATIONS

The Parties established several mechanisms for generating revenues from resource development activities to support the Convention's institutions. However, in the period before revenues are sufficient to cover all or part of the regime's operating costs each Commission member will contribute to its operation. Initially, each of the 22 members will contribute equal shares to the budget, but as soon as possible a more equitable formula will be established, by consensus, that will take into account each member's ability to pay (art. 35). **It is unlikely that revenues will significantly offset expenses for the foreseeable future.**

In the event that resource activities do commence, revenues will begin to offset some of the regime's expenses. At some point revenues may be able to cover all of the Minerals Convention's operating costs, and surpluses may be generated. What to do with possible revenue surpluses was one of the more difficult problems in the negotiations. Claimant states hoped that a portion of excess revenues automatically would be allocated to the relevant claimant in recognition of its 'special interest. The final text specified that excess revenues would be used in three ways:

1. to reimburse operational expenses paid by Commission members in years before revenues begin to offset some or all of the regime's expenses (art. 35(lb));
2. to promote scientific research in Antarctica by all Parties (especially by developing country Parties), particularly research related to the environment and resources of Antarctica (art. 35(la); and
3. to ensure that ''the interests of the members of Regulatory Committees having the most direct interest in the matter in relation to the areas in question are respected in any disposition of that surplus" (art. 35(7b)).

This last vague statement could be interpreted to apply primarily to claimant states. Given the other claims on excess revenues and the fact that all budgetary decisions—including allocation of excess revenues—require a consensus vote, it is far short of the guaranteed share of revenues that claimant states hoped to acquire.

The Convention specifies three methods for generating revenue:

1. Operators will be required to pay fees to cover the handling costs of notifications for prospecting and identification of an area and for applications for exploration and development;
2. Operators will be responsible for levies on exploration and development activities, where the principal purpose is to offset the operating expenses of the Convention; and
3. Operators will be obligated to make payments ''in the nature of and similar to taxes ,royalties, or payments in kind (art. 47(k)).

The amount Operators would be required to pay is not specified in the Convention. The Commission is to adopt general rules governing revenue at a later date. The relevant Regulatory Committee will specify the specific financial obligations of each Operator as part of each Operator's Management Scheme. Fees covering the administrative costs of notifications and applications are unlikely to be a burden to Operators. However, levies to finance the costs of the institutions and taxes, royalties, and other financial payments could be significant. These might be important factors for an Operator in determining whether to proceed with a project. Regulatory Committees may have difficulty specifying the amounts or percentages of Operator obligations. An Operator is unlikely to proceed unless there is a financial incentive to do so, that is, unless it can be assured of an adequate rate of return after these obligations are met. (Apps. A and B contain more information about development costs.)

OPERATORS AND SPONSOR STATES

The relationship between an Operator and its Sponsor in the Convention is important. On the one hand, Sponsors are to evaluate Operators and oversee their activities. For instance. they must ensure at each stage in the process that their Operators are qualified to undertake resource development activities without violating provisions of the Minerals Convention. In particular, they must ensure that Operators have the financial capacity and technical competence to respond to threats or harm to the environment. Sponsors must also ensure that Operators maintain a substantial and genuine link with them; that data and information supplied by Operators is acceptable; and that activities of their Operators do not infringe on the rights of other Operators.

On the other hand, Sponsors will need to support and defend the interests of their Operators. On behalf of Operators, Sponsors must notify the Commission in advance of prospecting, promote Operator interests in identifying areas for exploration and development, and submit applications for exploration and development permits to the Regulatory Committees. In helping to develop Management Schemes to guide Operator activities, the oversight and support roles of Sponsors intermingle and could potentially conflict.

Significantly, an Operator-at least one based in a free market economy like the United States—is free to choose its own Sponsor. The presumption that a multinational company with headquarters in the United States will want or need to select the United States as its Sponsor may not be correct, The selection of a Sponsor will depend in part on how willing the Sponsor is to defend Operator interests. One important factor in establishing industry confidence in the Minerals Convention is the degree to which the Sponsoring State will expedite procedural matters for the applicant and defend his position in the controversial situations that may arise from time to time.[17] If an Operator does not perceive that the United States can provide this help and support, it may seek a Sponsor elsewhere. Without a supportive Sponsor, Operators may find it too difficult to participate in Antarctic minerals activities.

Operators are also likely to consider a prospective Sponsor's procedural requirements. Sponsors with complicated or time-consuming procedures would be less appealing than Sponsors with easier ones, all other things being equal. Operators also might see some advantage in choosing as Sponsor the country claiming the area of interest. A claimant state, for instance, might be more inclined to cast its vote in favor of opening an area if an Operator selected that claimant to sponsor its activities and/or perhaps made other concessions that facilitated development.

The United States could establish elaborate regulations for potential Operators only to find no Operators interested in being sponsored by it. This will occur if standards in other countries are less stringent and if the United States does not offer offsetting advantages, However, if the United States stands behind its Operators, its support, given its longstanding leadership role in Antarctica, could be valuable. Conversely, its lack of support could hurt: the United States can always veto development at an early stage, and it has substantial influence at all stages to affect the outcome of decisions. Operators could find the United States to be a valuable ally.

LIABILITY AND RESPONSE ACTION

One of the most difficult issues the Parties faced was the issue of liability and response action for activities that result or threaten to result in damage to the Antarctic environment. The underlying difficulty involved ensuring that damages and injuries would be adequately compensated without making activities prohibitively difficult or expensive to undertake. Article 8 of the Convention establishes general provisions for liability and response action, but negotiators were unable to reach agreement on several important liability concerns. They decided that once negotiations on the Minerals Convention were complete, they would begin negotiating a separate Liability Protocol to the Convention. The Protocol is to be adopted by consensus and ratified by the same procedure as the Convention. Pending its entry into force, no exploration or development will be allowed.

The framework established in article 8 requires **that** Operators take "necessary and timely" response action for all activities that damage or threaten Antarctica's environment. Operators are ''strictly liable' for all environmental damage arising from mineral resource activities, including but not limited to clean-up and restoration costs. Strictly liable is defined as meaning an Operator is liable for damages whether it is later found at fault or not. Thus, for example, the Operator must pay if there is no restoration to the status quo ante following damage to the environment. How much is not specified. It is unclear who is entitled to payment when there is no personal injury or damage to private property. Presumably, damage payments would be collected and expended by the Commission. It is also presumed that claims by territorial claimants for environmental damage to claimed areas as such would not be permitted.

A contentious subject of the negotiations concerned the defenses or limits on liability that would be available to Operators. Two defenses are specified in the Convention (art. 8(4)):

- the Operator is not liable to the extent damage was caused directly by a natural disaster of exceptional character that could not reasonably have been foreseen, and
- by armed conflict, or by an act of terrorism against which no reasonable precautionary measures could have been taken.

The Operator's right to seek contribution or indemnity from another party that caused or contributed to the damage is unaffected, but this does not limit the Operator's liability to a plaintiff. Even a negligent plaintiff may collect damages from the Operator, Only if the plaintiff caused the damage by an intentional or grossly negligent act is the Operator relieved in whole or in part of the duty to pay for damages (art. 8(6)). Pursuant to this system, an

[17] Garrett, op. cit., footnote 14

Operator might well be liable for environmental damage if, for example, a ship crashes into the Operator's offshore drilling rig.

In addition, to the extent the Operator or some other source does not satisfy all claims, the Sponsoring State is liable for damage caused by the Operator that would not have occurred had the Sponsoring State adequately supervised the Operator (art. 8(3)). The Sponsoring State is also responsible for ensuring that its Operators maintain the necessary financial and technical capacity to undertake any required response and to meet any potential liability. Any Sponsor that was lax in this regard could be liable for a large proportion of damages in the event of an accident. However, Parties could not agree that the Sponsoring State would be required to satisfy unmet claims on its Operator if the Sponsoring State carried out its duties in a responsible manner.

Permits for exploration and development may not be issued until the Liability Protocol enters into force. Prospecting, on the other hand, may go forward after the Minerals Convention is ratified. Pending the entry into force of the Protocol, claims against prospectors may be brought in national courts pursuant to provisions of the Convention and national law implementing those provisions (art. 8(10)).

The Minerals Convention specifically states that the Protocol include rules and procedures on liability to protect the Antarctic environment, including appropriate limits on liability, where such limits can be justified; ensuring that means are available for immediate response action where the Operator is incapable of doing so; and ensuring that all liability is satisfied (e.g., in those cases where the Operator is not financially able to meet its obligations in full or where damages exceed limits on liability) (art. 8(7)). A fund or funds for covering outstanding claims may be established, to be financed by Operators or on an industry-wide basis. Presumably, the Protocol will also have to interpret the defenses to liability noted above.

The Minerals Convention and accompanying Protocol aim to establish a very stringent liability regime that reflects underlying environmental values. However, mining companies and their Sponsors and insurers may be reluctant to accept such potential liability if it is open-ended. Thus, the economic acceptability of these provisions depends on the Protocol that remains to be negotiated and, in particular, on any liability limits fixed in the Protocol and associated fund arrangements. The Convention also leaves open the possibility of establishing an international claims tribunal in the Protocol by which claims against Operators may be assessed and adjudicated.

The liability provisions of the Convention deal almost exclusively with environmental considerations. All that is said about liability for personal injury to or death of a human being or injury to property not involving environmental or related damage is that it is regulated by ' 'applicable law and procedures" (art. 8(5)). The Protocol may be an appropriate place in which to define these issues more fully.

ENVIRONMENTAL PROTECTION AND THE MINERALS CONVENTION

The environmental requirements and sanctions of the Minerals Convention establish a potentially strong environmental regime. At this stage, it would appear that the main uncertainty with the framework established by the Convention is how compliance and enforcement would work and how strong the regime would be in practice. No mineral resource activities are to take place unless information adequate to enable informed judgments is available; unless it is judged, based on assessment of possible impacts, that the activity would not cause significant effects on air and water quality or significant changes in atmospheric, terrestrial, or marine environments or significant changes in the distribution, abundance, or productivity of populations of species of fauna or flora; unless technology and procedures are available for safe operations; or unless there exists the capacity to respond effectively to accidents (art. 4). Moreover, Regulatory Committees may suspend, modify, or cancel Management Schemes and exploration and development permits, and they may impose monetary penalties for failure to comply with the provisions of the Convention (art. 51).

The environmental provisions of the Minerals Convention appear to be as strong as+or stronger than-similar provisions in other interna-

tional agreements. However, although the text forms the basis for a strong environmental regime, many points are not defined, such as what constitutes a ''significant' environmental impact and how much information about a prospective area is "adequate" or "sufficient." The definitions of these terms vary and may in the end be determined on the basis of political considerations. Even apparently clear parts of the text may be subject to different interpretations, so a strong environmental regime is hardly ''writ in stone. "[18]

Also, environmental concerns, mostly abstract by necessity at this stage, may be brushed aside if and when resource development becomes a reality. Thus, when environmental regulation becomes a practical rather than anticipatory necessity, a growing number of states may regard strict environmental requirements as an impediment to their investors—both directly and because the state that sponsors mining may itself become liable for inadequate supervision of its Operators. [19] Some states may argue that a strict environmental regime favors the most advanced companies from the wealthiest states. On this basis, less developed countries may be inclined to pass less strict rules to attract Operators. However, the unusually strong environmental requirements of the Convention itself, coupled with compulsory dispute settlement and a strong Liability Protocol, may be sufficient insurance against the possibility that some states may be significantly less concerned about the environment than others.

Even where environmental regulations are strict, ensuring compliance with them is difficult and requires political will. The Convention has general provisions concerning compliance in article 7 and also provides for inspection, monitoring, reporting on Operator activities, and for observers in Commission and Advisory Committee meetings. However, ''enforcement issues are difficult to agree on in the Antarctic context, because they relate so directly to the rights of a sovereign state in its territory. Both claimants and nonclaimants wish to avoid any provisions in the Convention that prejudice their position on sovereignty in Antarctica. ' '[20] Each Party is asked to take appropriate measures ''within its competence' (this term is used to avoid prejudicing positions on sovereignty) to ensure compliance with the Convention. Specific rights are not assigned, also to avoid implications of sovereignty.

The Convention thus presumes a system of "flag state enforcement' for environmental protection, which may be less effective than other systems. But other systems of enforcement are impractical because of the sovereignty issue. At present, Parties are largely responsible for policing themselves with respect to scientific and other activities carried out under the auspices of the Antarctic Treaty. The Treaty System has no centralized review mechanism or regulatory authority to oversee national activities in Antarctica, and at present the ATCPs are reluctant to criticize each other's activities. Criticism might easily lead to uneasy discussions about who is entitled to what rights and who may enforce obligations. For example, environmental groups have criticized French construction of an airstrip in an environmentally sensitive area near the Dumont D'Urville research base. But other Treaty states do not have the authority to review the French plans. The Convention improves on this situation by more clearly defining binding legal rights and obligations and subjecting Parties to binding dispute settlement in most cases.

Some have suggested that an international environmental protection agency be established for Antarctica. The difficulty with this proposal, again, is that an agency with sufficient independent authority would be virtually impossible to establish in the multilateral context of Antarctica and given the reality of the dispute over sovereignty. Given these constraints, an Antarctic EPA would not necessarily have any advantages over the system established in the Minerals Convention.

The power of Regulatory Committees to suspend, modify, or cancel Management Schemes is important. Support for outright cancellation of projects perceived to be causing unforeseen damage to the environment may be difficult to achieve once activities have started; however, support for modifications to Management Schemes if problems arise

[18] B. H, Oxman, ''Ev~uating the Antarctic Minerals Convention: The Decision-Making System, ' OTA contractor report, November 1988, p. 7.

[19] Ibid., p. 13.

[20] Kimball, op. cit., footnote 4, p. 18.

ought to be much easier. Ultimately, the effectiveness of environmental protection under the Minerals Convention rests largely with the political will of the Parties.

DISPUTE SETTLEMENT

The Convention specifies that the Parties shall submit to compulsory arbitration or adjudication of certain disputes (table 3-7). This system could prove useful when a state is accused of violating the Convention (e.g., by failure to fulfill its duty to supervise compliance by its Operators with environmental requirements). In addition, the Convention contemplates the establishment of an arbitral mechanism pursuant to which Operators can challenge certain decisions by a Regulatory Committee regarding their Management Schemes and permits.

However, the Convention text places significant constraints on the jurisdiction of any tribunal to review ''the exercise by an institution of its discretionary powers in accordance with this Convention' (art. 57(5)). It is unclear how broadly these constraints will be construed by a tribunal, They could be construed in a manner that is consistent with the traditions of many countries regarding judicial review of administrative agencies, namely that it is up to the reviewing tribunal to decide whether the agency had the discretion to act as it did under the Convention, but that it is not the function of the tribunal to substitute its judgments for those of the agency. It is also possible for the constraints to be construed to require almost complete deference to any decision by the Commission or a Regulatory Committee that can be characterized as ''discretionary. ''

The United States may wish to include an interpretive statement on this topic in connection with any instrument of ratification. Such a statement could note that the constraints on the jurisdiction of a tribunal to review the exercise of discretion by an institution established by the Convention do not preclude it from determining whether that institution had the power to decide as it did under the Convention, whether the decision violated a substantive or procedural provision of the Convention, or whether that organ otherwise exceeded or abused its powers.

Table 3-7-Dispute Settlement

General provisions:
- Either' the International Court of Justice (ICJ) or the Arbitral Tribunal established by the Convention may be used to settle disputes arising from the interpretation or application of the Convention, Art. 56.
- Parties to the dispute are requested, first, to try to settle disputes among themselves by any agreed means, Art, 57(1).
- Disputes are automatically referred to one of t he above dispute settlement bodies if agreement cannot be reached. Art. 56 and 57.
- Neither the ICJ nor the Arbitral Tribunal shall have authority to settle disputes related to claims. Art, 57(4).
- Neither the ICJ nor the Arbitral Tribunal shall have authority to settle disputes between Parties with regard to the exercise by an institution of its discretionary powers. Art. 57(5).
- Any Party may exclude some types of disputes from being referred to a dispute settlement body without its consent, but may not do so regarding disputes about provisions of the Convention: a) on protection of the environment, b) on compliance with the Convention, c) on response action and liability, d) on inspection, e) on non-discrimination, f) on other uses of Antarctica, and g) on prospecting. Art. 58 (1a-g).
- Additional dispute settlement procedures for Operators will be established by the Commission, for example, providing a means by which an Operator may dispute a decision to decline a Management Scheme. Art. 59.

Institutional oversight
- The Arbitral Panel is responsible for settling all disputes submitted to it. Annex Art. 10.
- A dispute may be referred for discussion to the Institution which adopted the instrument in question if the dispute is still unresolved after 6 months of consultation by the disputing parties. Art. 57(3a).

Obligations of disputing parties:
- To consult among themselves as soon as possible, using any agreed means to resolve the dispute, Art. 57(1),
- If unable to resolve the dispute among themselves, to comply with the decision of the Arbritral Tribunal (Annex Art, 11) or ICJ,
- To provide the Arbitral Tribunal, where relevant, with all applicable documents and information, and enable it, when necessary, to call witnesses or experts and receive their evidence. Annex Art. 8.

SOURCE" Office of Technology Assessment, 1989

* * *

The Minerals Convention establishes the framework for deciding what, if any, resource activities will be allowed to take place in Antarctica and for regulating any activities that are allowed. What do we currently know about what mineral resources may at some time be worthwhile to develop and what effect development could have on the environment? These are the subjects of the next two chapters.

Chapter 4

Potential Mineral Resources in Antarctica

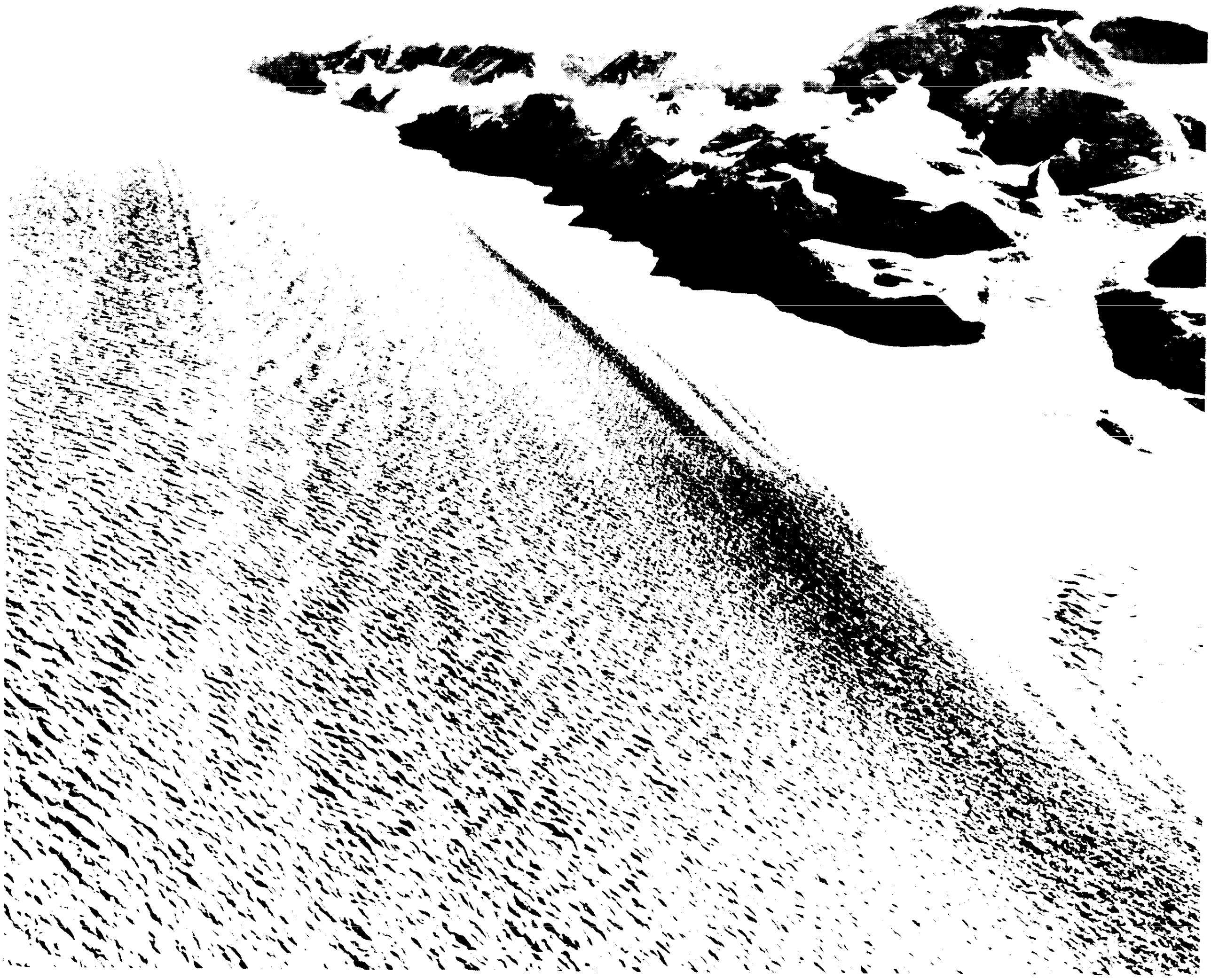


Photo credit: U.S. Geological Survey

Byrd Glacier

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Potential Mineral Resources in Antarctica

SUMMARY

Scientists have discovered occurrences (small amounts) of several minerals **in Antarctica, but there are no known mineral deposits of commercial interest.** Mineral deposits are likely to have formed in Antarctica, just as they have on adjacent continents once connected to Antarctica, but because nearly 98 percent of the continent is covered by ice, few mineral deposits are likely to be exposed.

Development of any resources found in Antarctica will be expensive. At current prices, a metallic mineral deposit found in Antarctica would not be economic to develop unless of world class size or grade with an in-place value of $200 to $400 per ton, depending on location. An oil field would have to contain at least several billion barrels of recoverable oil. Even at this size, world oil prices would at least have to double before the field could be economically developed. Mineral development in Antarctica could be driven by political or strategic motives rather than by a quest for profit. Some believe these motives may become important; OTA does not view them as being as significant as market incentives.

The probability of finding mineral deposits is highest on the Antarctic Peninsula, in part because more rock is exposed there. Outside the Antarctic Peninsula the probability of finding mineral deposits in exposed areas is small. Based on the geology of the Peninsula region, the deposits most likely to be found are base metals (copper, lead, and zinc) and precious metals (gold and silver). The hard mineral deposits with the best prospects for economic recovery in Antarctica are low-volume, high-value deposits, such as gold, particularly if such deposits can be found in accessible locations. The Dufek intrusion in the northern Pensacola Mountains could host platinum-group metals, chromium, copper, cobalt, and nickel. However, discovery of a mineral deposit in a relatively inaccessible inland area, such as the Pensacola Mountains, would greatly diminish its prospects for economic recovery. Virtually all of the potentially economic minerals known to occur in Antarctica are currently abundant in other, more accessible areas of the world.

The offshore sedimentary basins surrounding Antarctica offer the best prospects for petroleum exploration. The Weddell and Ross embayments in West Antarctica, and Prydz Bay and the Wilkes Basin in East Antarctica are among the basins most likely to contain petroleum, based on what is known about the thickness, organic content, age, and thermal history of the sedimentary rock. However, until these basin areas are more fully explored, particularly by drilling, meaningful estimates of petroleum potential cannot be made. For the most part, the sedimentary basins on the surrounding continents that have analogs in Antarctica are not major petroleum producing provinces.

INTRODUCTION

The resource potential of Antarctica is receiving increased global attention as a result of technological developments, continued scientific research, and the drive to develop additional sources of energy and minerals supply. At present there are no known economic mineral deposits in Antarctica. However, scientists postulate that high grade mineral deposits exist there, as they do in all large land masses. Such mineral deposits would be difficult to locate: the extensive ice cover and limited opportunity for exploration are likely to preclude discovery of all but a tiny fraction of any potential ore bodies. Furthermore, the mineral deposits most likely to be economic, which would be high concentrations of metals in ore bodies, tend to be localized features hidden by overburden or otherwise difficult to locate even under more hospitable conditions. In addition, since the onset of glaciation, enrichment processes related to near-surface weathering and water movement, such as occur in more temperate regions, would not have occurred in Antarctica. Despite these caveats, it is entirely possible that some mineral deposits might be found in Antarctica which could at some future time be of sufficient economic value that their extraction might be considered.

A great variety of mineral occurrences have been found in Antarctica, but no mineral occurs in sufficient concentration or grade to be commercially minable. The term ‘‘mineral occurrence’ is used to refer to small amounts of a mineral that in larger volumes in other parts of the world has been mined or is an indicator of a minable deposit. The term ''mineral deposit" is used to refer to a large amount of some mineral without reference to its economic value. The term ''mineral commodity' is used here to refer to the mineral itself or the refined product made from it. Other than ice, only two mineral commodities, a sedimentary iron ore formation in the Prince Charles Mountains of East Antarctica and coal beds in the Transantarctic Mountains, are known to be of sufficient size even to be classified as "deposits." Because of their inaccessibility in Antarctica and abundance elsewhere, neither is considered a commercial deposit.

Mineral deposits can be divided into several categories based on a combination of geologic and economic criteria according to a system developed jointly by the U.S. Geological Survey and the U.S. Bureau of Mines. [1]Known deposits are either demonstrated or inferred and can range from subeconomic resources to reserves (box 4-A). Reserves are identified mineral deposits that are economically recoverable with current technology. Subeconomic resources are those that have been identified but are not recoverable under current economic conditions and technology. In Antarctica, identified fresh water (ice), coal, and iron ore deposits would be classified as subeconomic. **Speculative resources are unknown or undiscovered deposits outside districts where economically extractable mineralization is known to have occurred. With few exceptions, the mineral resources of Antarctica would be classified as speculative at this time.**

While the classification of mineral resources will change with time, most experts would agree that classification of Antarctic minerals is not likely to change before the end of this century and probably not for several more decades. Any change would depend on what, if anything, is found, where it is found, and the supply and demand situation at the time of discovery. To be economically viable at current prices, a metallic mineral deposit in Antarctica would likely have to be world class in size or grade and have an ore value of $200 to $400 per ton depending on its location. For a gold deposit, this would be approximately 10 times the grade of

Photo credit. Am Hawthorne

Transantarctic Mountains en route to the South Pole from McMurdo.

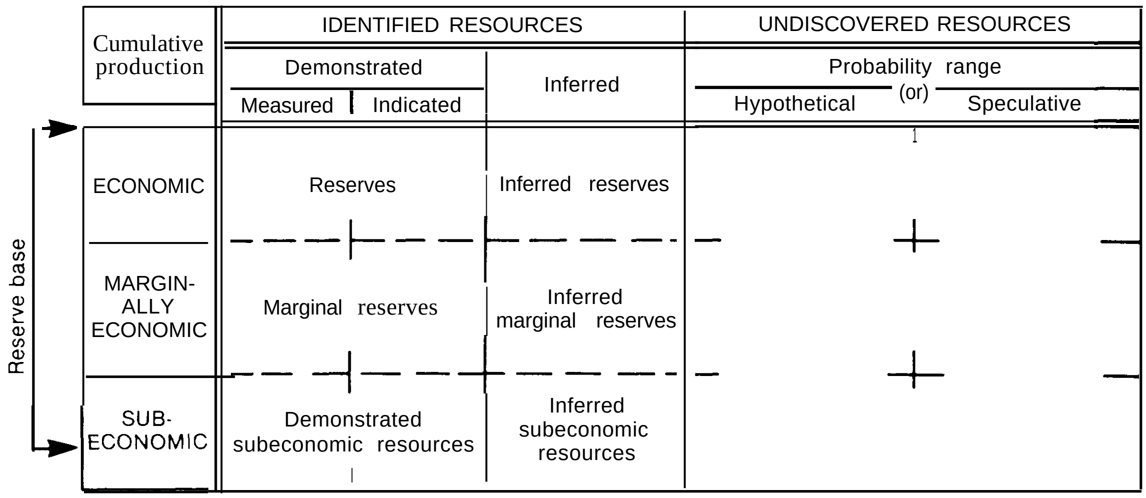
deposits currently being developed in the western United States. In the case of petroleum, afield would have to contain several billion barrels of recoverable oil or about three orders of magnitude larger than would be economic onshore in the United States.

The following sections discuss the geological inferences regarding the formation and location of mineral deposits in Antarctica, assess the probabilities of discovering Antarctic mineral deposits, and offer some perspective on a selection of mineral commodities that might exist in Antarctica. The individual commodities discussed are not intended to represent all minerals likely to be found in Antarctica, but were chosen to provide a selection of

[1] ''Principles of a Resource/Reserve Classification for Minerals, from Geological Survey Circular 831, 1980, *Mineral Commodity Summaries 1988,* U.S. Bureau of Mines, pp. 184-187.

Box 4-A—Mineral Resources and Reserves

A general classification for describing the status of mineral occurrences was developed by the ***U.S.*** Geological Survey and the U.S. Bureau of Mines in 1976. The so-called ‘‘McKelvey Box” named after the then-director of the USGS, Vincent McKelvey, further simplified the understanding of the of the economic relationships of the mineral-resource classification system:



The system is based on the judgmental determination of present or anticipated future value of the minerals in place according to the opinions of experts. Below are the economic definitions on which the resource-classification system is based:

- *Resource*: Naturally occurring mineral of a form and amount that economic extraction of a commodity is potentially feasible.
- *Identified Resource*: Resources whose location and characteristics are known or reliably estimated.
- *Demonstrated Resource*: Resources whose location and characteristics have been measured directly with some certainty (*measured*) or estimated with less certainty (*indicated*).
- *Inferred Resource*: Resources estimated from assumptions and evidence that minerals may occur beyond where resources have been measured or located.
- *Reserve Base*: Part of an *identified resource* that meets the economic, chemical and physical requirements that would allow it to be mined, including both measured and indicated resources.
- *Reserves*: Part of the *reserve base* that could be economically extracted at the time of determination.
- *Marginal Reserves*: Part of the *reserve base* that at the time of determination borders on being economically producible.
- *Undiscovered Resources*: Resources whose existence is only postulated.

plausibe examples covering a range of geological environments. Data on mineral occurrences in ‘Antarctica in the following sections are largely taken from publications of the U.S. Geological Survey and other publications and papers in press by U.S. Geological Survey personnel. Data on world markets were abstracted from the U.S. Bureau of Mines, Mineral Commodity Summaries. Data on coal and uranium are from publications of the Energy Information Administration of the U.S. Department of Energy and the Organization for Economic Cooperation and Development's Nuclear Energy Agency.

The ratio of reserve base (see box 4-A) to current production was used in the sections devoted to specific mineral commodities to gain perspective on the future supply and market potential. These ratios are presented only for comparative purposes. Even in cases where the reserve base is large relative to current production (long term supply), this does not necessarily imply that if a high grade opportunity can be found in Antarctica, it would not attract interest. The reserve base rather than reserves was chosen because it includes not only reserves, which are currently economic, but also resources that are marginally economic and, to an undefined extent, some of the subeconomic resources. The reserve base is a broader term than reserves and, thus, for the purpose of defining future supplies, perhaps a better indicator. The broader category of "resources" could also have been used, resulting in a larger ratio. This might be more appropriate because, with few exceptions, the mineral resources of Antarctica would be classified no higher than speculative at this time. However, since for the purpose of projecting a future market it must be assumed that a deposit in Antarctica has been found, it would seem more realistic to project it in competition with known mineral resources reasonably likely to be developed in the future.

Current production is the other aspect of the reserve base to production ratio. Considering the variables in past minerals production, no attempt was made to project future production or to assess future needs based on changes in technology. Beyond short term fluctuations, decreases in annual production rates are generally less likely than increases. Obviously, higher annual production rates would reduce reserve base to production ratios, assuming there were no additions to the reserve base. Historical trends would suggest, however, that there will be additions to the reserve base. Projecting the extent to which this may offset increased future minerals production would depend, to some extent, on one's level of optimism.

Mineral development in Antarctica, if it were to occur, could also be driven by political or strategic concerns rather than by economic viability. Some believe that these concerns may become important. Therefore, strategic and critical materials concerns of the United States, if any, are also briefly summarized for the commodities discussed.

GEOLOGICAL ASSOCIATIONS

Antarctica can be divided into two parts on the basis of geology and topography, East Antarctica and West Antarctica. These areas are separated by the long mountain belt of the Transantarctic Mountains (figure 4-l). The line of division corresponds roughly to the division between the Eastern and Western Hemispheres or more closely to the 30°W. 150°E. meridian. East Antarctica is roughly twice as large as West Antarctica and is geologically older. It is a vast ice-covered plain with mountain peaks and ice-free areas only around the edges. Completely ice-covered mountain chains lie under the ice cap.

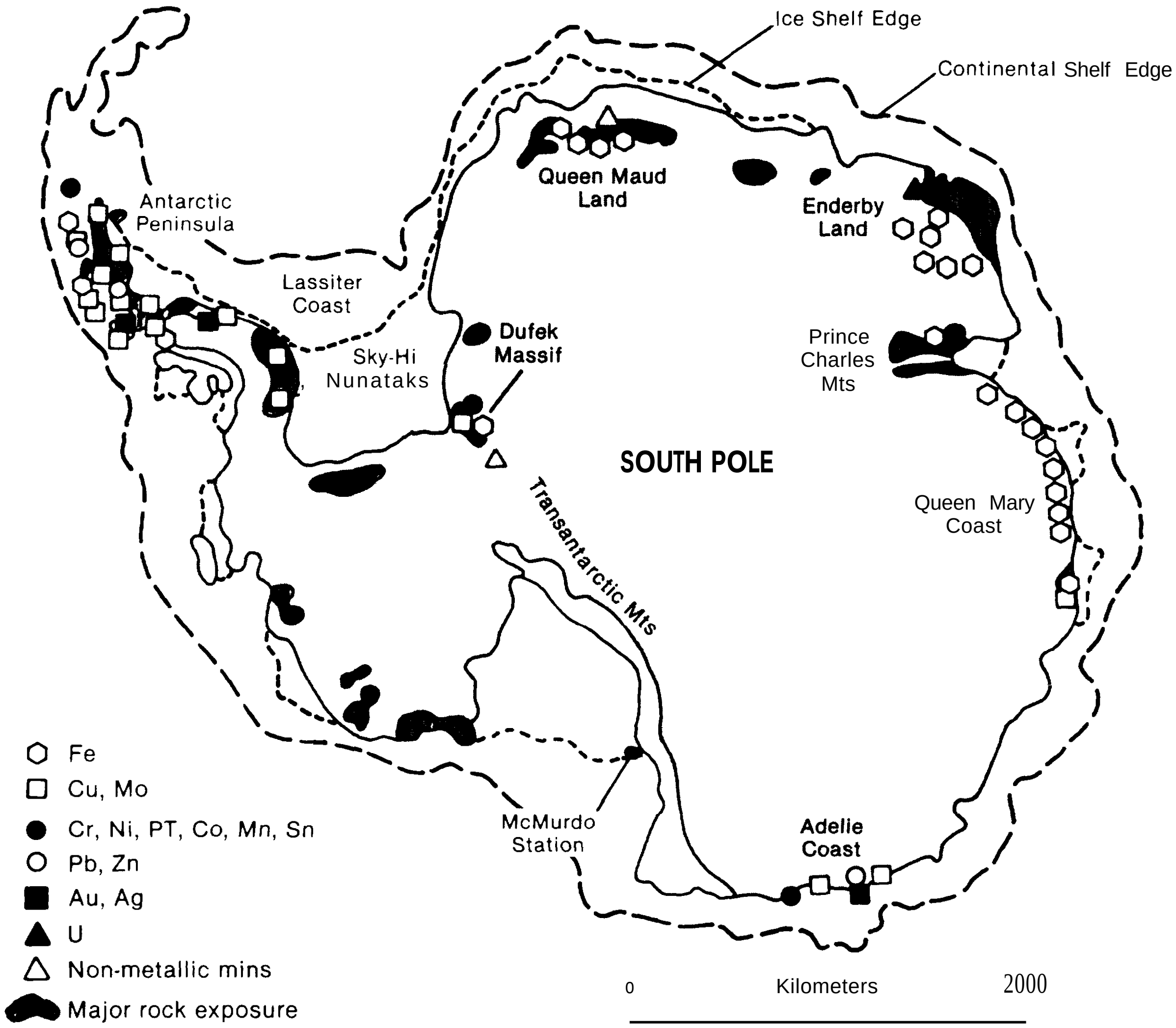
East Antarctica is mostly a **shield**[2] area consisting of very old (Precambrian) igneous, metamorphic, and deformed sedimentary rocks locally overlain by younger (Paleozoic through lower Mesozoic) sedimentary and igneous rocks of the Beacon Supergroup and their equivalents (box 4-B). The younger rocks are generally flat-lying and are especially widespread in the Transantarctic Mountains, which border the East Antarctic shield and provide a link to the younger sedimentary and volcanic rocks of West Antarctica. The geological picture, in general, is one of progressive addition through West Antarctica of younger belts of rock to the East Antarctic shield.

The rocks of East Antarctica are rarely exposed except along the coast and in the Transantarctic Mountains. In a few places near the coast, ice-free areas are found as ''dry valley s,' where receding glaciers and arid climate have left moraines and brackish lakes on the valley floor. The shield of East Antarctica contains a wide variety of mineral occurrences of a wide variety, as do shield areas of other continents. In contrast to the East Antarctic shield, relatively few mineral occurrences of interest have been found in the Transantarctic Mountains—

[2] Terms that appear in the glossary (app. G) are in bold the first time they appear.

Figure 4-l-Antarctic Mineral Occurrences

Antarctic Mineral Occurrences



SOURCE. U.S. Geological Survey, 19SS,

with the exception of the Dufek Massif in the northern Pensacola Mountains near the Weddell Sea.[3] The Dufek intrusion is one of the world's largest layered mafic igneous complexes and is similar in certain respects to the mineral-rich Bushveld complex of South **Africa.**

Mineral deposits of moderate size and grade could be present in the Transantarctic Mountains. Among the most likely host rocks for ore mineralization would be:

- layered mafic intrusions such as the Dufek (platinum-group metals, chromium, cobalt, nickel);

[3] Peter D. Rowley, Paul L, Williams, and Douglas E. Pride, "Mineral Occurrences of Antarctica,' *Petroleum and Mineral* Resources *of Antarctica,* John C. Behrendt (cd.), U.S. Geological Survey Circular 909, 1983, p. 27.

Box 4-B-Geologic Time Scale

Time interval	Major event	Began (millions of years ago)	Duration in millions of years
Cenozoic Era			
Quaternary Period			
Holocene Epoch	Man abundant	0.01	0.01
Pleistocene Epoch	Man appears	1,6	1.59
Tertiary Period			
Pliocene Epoch		5.3	3.7
Miocene Epoch	Mammals diversify Grasses spread	23.7	18,4
Oligocene Epoch		36.6	12.9
Eocene Epoch	Mammals develop rapidly	57.8	21,2
Paleocene Epoch		66.4	8.6
Mesozoic Era			
Cretaceus Period	Dinosaurs become extinct, Flowering plants appear	144	77.6
Jurassic Period	Birds appear	208	64
Triassic Period	Primative mammals appear, Dinosaurs appear	245	37
Paleozoic Era			
Permian Period	Reptiles appear	286	41
Pennsylvanian Period	Insects abundant	320	34
Mississippian Period		360	40
Devonian Period	Fish abundant	408	48
Silurian Period	Amphibians appear Land plants and animals appear	438	30
Ordovician Period	Fish appear	505	67
Cambrian Period	Marine invertebrates appear	570	65
Precambrian Era	Simple marine plants	3,800?	3,230?

SOURCE: Geological Society of America, 1983.

- sequences of marine sediments that incorporate substantial proportions of intermediate to **silicic volcanic** materials (copper, lead, zinc, silver); and
- porphyritic intrusions of intermediate t. sili. cic composition (copper, molybdenum, silver, gold).[4]

West Antarctica contains mountain ranges and isolated peaks, called nunataks, that extend through the ice and snow cover. Overall, the West Antarctic ice surface is much lower topographically than that of East Antarctica. If the present ice cover were removed, West Antarctica would appear as a series of scattered islands or group of islands surrounding the submerged Byrd Basin, which would connect with the Ross Sea, the Amundsen Sea, and the Weddell Sea.

The exposed rocks of West Antarctica in the Ellsworth orogen, between the Ross and Weddell Seas, are Paleozoic sediments and Mesozoic intrusions generally devoid of known metallic mineralization. The probability that significant mineral deposits are present in this zone appears to be poor. The thick sequences of sedimentary rocks like those exposed in the Ellsworth Mountains do not appear likely to host metallic ores, although the presence of

[4] N.A. Wright and P. L. Williams, *Mineral Resources of Antarctica*, U.S. Geological Survey Circular 705, 1974, p. 22.

Photo credit: Ann Hawthorne

Collecting samples on Mt. Oliver in Upper Wright Valley.

Mesozoic intrusive rocks in the Whitmore Mountains suggests somewhat more favorable conditions there.[5]

A substantial part of the Antarctic Peninsula consists of igneous intrusions of Mesozoic and Tertiary age that form a composite magmatic arc; arc-related volcanic and sedimentary rocks of similar age also occur. The volcanic and intrusive rocks of the Antarctic Peninsula belong to the **calc-alkaline** magmatic suite, rocks which in other parts of the world are associated with copper-lead-zinc ores. Consequently, the peninsula is a favorable geologic environment for copper, molybdenum, lead, zinc, tin, tungsten, silver, gold, and other mineral deposits.

Relationship to Adjacent Continents

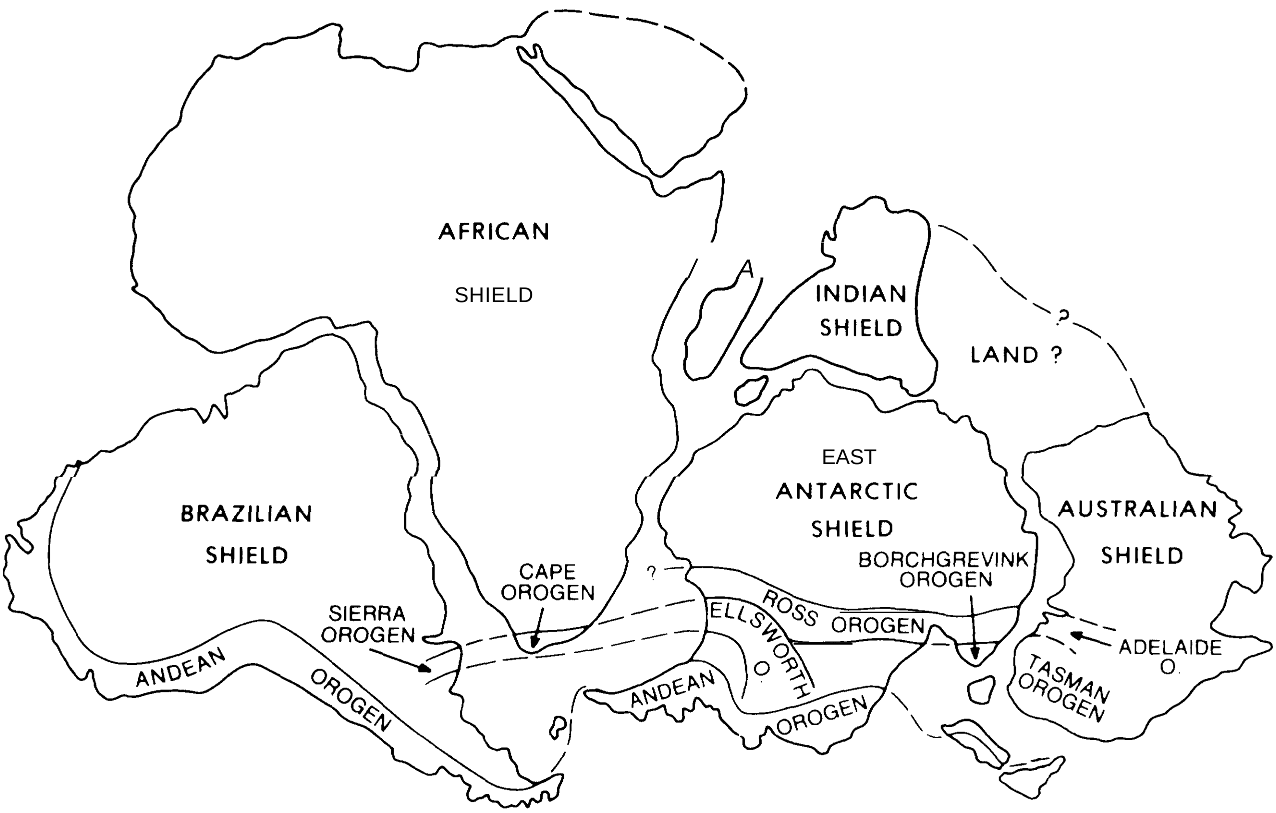
One way of assessing the mineral potential of Antarctica is by analogy with mineral deposits found in similar geologic settings on surrounding continents, Antarctica's relationship to the surrounding continents can be explained by the process of plate tectonics. According to the theory of plate tectonics, the Earth's rigid outer layer, called the **lithosphere, is** a mosaic of slablike plates that move with respect to one another at rates averaging a few centimeters per year. The plates ride on a hot, plastic layer of the Earth's mantle called the **asthenosphere.** Plate movements are thought to be driven by convection currents or density changes in the mantle and cause a seafloor-spreading process, in which molten material from the asthenosphere rises through the lithosphere to form new ocean crust at ridges on the ocean floor. Newly created oceanic crust moves outward from the mid-ocean ridge spreading centers. if the oceanic crust meets a continent on another plate, it may sink under the continent and be drawn down into the mantle in a process called subduction, (This process occurs along the Pacific coast of South America where Pacific crust plunges beneath the western margin of the continent.) Alternatively, if a continent is on the same plate as the new seafloor, it is carried along as though on a raft. (New ocean floor generated in the Atlantic Ocean carries the American continent westward toward the Pacific.) In general, the continents are carried passively by the lithospheric plates, which grow by seafloor spreading and occasionally collide to form mountain belts such as the Himalayas.

Reconstructing the former locations of continents based on the geologic record of plate movement indicates that approximately 200 million years ago the major land masses of the Southern Hemisphere, including what is now Antarctica. were joined together into a giant continent called **Gondwana** or Gondwanaland. In particular, the geological record shows that the western two-thirds of Australia, India, and part of southern Africa were close to East Antarctica at least during the Late Paleozoic and Early Mesozoic Eras.

The core areas of the continents are the old Precambrian shields. In the reconstruction of Gondwana, the Brazilian shield, African shield, Indian shield, Australian shield, and East Antarctic shield are all brought into close juxtaposition like pieces *of* a puzzle (figure 4-2). South America, though not

[5]Ibid., p. 23.

Figure 4-2--Geologic Provinces of Antarctica and Their Relationship to Adjacent Gondwana Continents



SOURCE: J.C. Behrendt, "Are There Petroleum Resources in Antarctica?" *Petroleum and Mineral Resources of Antarctica*, J.C. Behrendt (cd.), U.S. Geological Survey Circular 909, 1983, p 6.

contiguous with East Antarctica, was close to Africa.[6] Numerous mineral occurrences are found in the shield of East Antarctica. Many of these occurrences are similar to the mineralization of major economic deposits in comparable shield areas f the adjacent continents, These major deposits include **iron-formations** and bedded manganese in Australia, India, and Africa; conglomeratic **placer** gold-uranium deposits of the Witwatersrand *in* South Africa; chromite, nickel-copper, platinum, and magnetite-vanadium deposits of the **stratiform** Bushveld intrusion of South Africa; copper-cobalt deposits of Zambia and Zaire; nickel deposits in intrusions in Australia; gold deposits in mafic volcanic rocks in Australia; lead-zinc-copper-silver deposits of Mount Isa and Broken Hill, Australia; and diamond-bearing pipes of South Africa, India, and Australia.[7] The Brazilian shield also contains important deposits of these types. Thus, since the shield areas of the adjacent continents in the Gondwana reconstruction have major mineral deposits similar to the types of mineralization found in the East Antarctic shield, it would seem reasonable to expect that similar deposits were formed in Antarctica,

Not only are the shield areas related, but analogs can also be found among the other geologic provinces of Antarctica. The Ross deformational belt of the Transantarctic Mountains extends into central Australia. The Flinders Ranges north of the city of

[6] Ibid., pp. 18-19.

[7] Peter D. Rowley, Paul L. Williams, and Douglas E. pride, ' 'Metallic and Nonmetallic Mineral Resources of Antarctica, " *The Geology of Antarctica,* R.J. Tingey (ed.), Oxford University Ress (in press).

Adelaide lie within the Adelaide orogen and appear to correlate with parts of the Transantarctic Mountains. Numerous deposits of copper with associated gold, lead, zinc, silver, barium, manganese, antimony, and other metals are found in the Flinders Ranges in rocks of Late Precambrian and Early Paleozoic age. The deposit types include veins, stockworks, and replacement bodies generally related to Early Paleozoic igneous activity. Porphyry copper deposits and stratiform lead-zinc deposits are also found in the area. In the same general area is the recently discovered ore body at Roxby Downs, which is rich in copper, gold, silver, uranium, and rare-earth minerals. Further to the east, a belt referred to as the East Australian erogenic province (also called the Tasman orogen) consists of progressively younger sediments, volcanic rocks, and intrusions extending into the Early Mesozoic. This province, a portion of which geologically resembles part of north Victoria Land (the Borchgrevink orogen) in Antarctica, contains deposits of copper, lead, and zinc associated with submarine volcanism and tin, tungsten, molybdenum, bismuth, gold, and other metals apparently associated with subsequent **granitic** intrusions.

The extension of the Ross orogen toward Africa is less clear, but radiometric dating suggests that metamorphic activity occurred in eastern Africa at roughly the same time as the Ross orogeny, but no ore deposits have been found that can be associated with this event. The younger Cape orogeny of southernmost Africa strongly folded Late Paleozoic rocks but did not produce any metamorphism, intrusion, or ore mineralization. This event could be correlated with the Ellsworth orogen of Antarctica, which has also been found to be lacking significant mineral occurrences. In South America, the region comparable to the Ellsworth orogen lies between the shield and the Andes and has relatively few ore deposits, particularly in the Paleozoic to Lower Mesozoic stratigraphic section.

In general, it may be useful to think of the Transantarctic Mountains and West Antarctica as representing a set of Paleozoic to Early Mesozoic orogens that are progressively younger away from the East Antarctic shield toward the Pacific, Mineralization generally decreases in intensity eastward in Australia (this would be toward the Pacific Ocean in Antarctica; see figure 4-1) and is even weaker in

Photo credit: Ann Hawthorne

Helicopter leaving Mt. Feather after ferrying geology field part to site. Helicopters are indispensable in Antarctica.

New Zealand. Thus, by analogy, mineralization may decrease westward in West Antarctica exclusive of the younger Andean orogen. Consequently, the probability that significant mineral deposits are present in Antarctica in the zone between the Transantarctic Mountains and the Andean orogen would seem to be poor.

The youngest geologic province of Antarctica is the Andean orogen. The Andean magmatic and deformational belt extends northward from the Antarctic Peninsula through the Andes of South America, and in the opposite direction from Ellsworth Land and Marie Byrd Land through New Zealand to form the southern margin of the currently geologically active circum-Pacific volcanic belt. In the northern and central Andes, this belt is one of the richest metal-producing areas of the world. However, the southern Andes are not as rich in mineral deposits as the northern and central Andes. The geologic break seems to be where the Chile Ridge is subducted beneath South America at the boundary of the Nazca and Antarctic plates. Subduction of the oceanic plate is still active to the north but has slowed or stopped to the south where the Antarctic plate has moved at an acute angle to South America. Compared to the mineral-rich northern and central Andes, where ores tend to be localized near the tops of intrusive masses, the southern Andes and Antarctic Peninsula have a different geological history. In the peninsula, glaciation may have more deeply eroded the intrusive bodies, removing the tops where ore deposits may have been located.[8] The different geological history and environmental conditions suggest that the Antarctic Peninsula, Ellsworth Land, and Marie Byrd Land may be less richly mineralized than the north and central Andes. Nevertheless, by analogy with the Andes, the Antarctic Peninsula appears to be one of the more likely places in Antarctica for significant **base-metal** deposits and possible associated gold and silver.

Offshore Shelf Areas

Marine sedimentary basins are of primary interest to petroleum geologists. The fragmentation of Gondwana, which began about 175 million years ago, with the final split beginning about 28 million years ago, led to the deposition of thick sequences of Cretaceus and Tertiary sediments in mid-continent rift basins and on the newly created continental shelves where formerly the continents had been joined. Sediments of these ages also accumulated in basins that were later uplifted to become parts of the continents. Seismic surveys and exploratory drilling for petroleum have now been carried out on almost all the land and continental shelves of those areas that once touched Antarctica. Several relatively modest oil and gas fields have been discovered in southern South America, southern Africa, Australia, and New Zealand. Through the Gondwana reconstruction, these producing areas can be related to specific regions of Antarctica. However, this does not assure that petroleum will be found in the analogous areas in Antarctica due to differences in time of formation, sediment thickness, history of deformation, migration of any hydrocarbons, and other factors. For example, if oil producing sediments accumulated off Australia along time after the breakup of Gondwana, this would not necessarily be evidence of oil in an adjacent area of Antarctica.

Several petroleum producing areas on the adjacent continents may have analogs in Antarctica. The San Jorge and Magallanes Basins are petroleum producing regions in Argentina that can be related in a number of ways to the Larsen Basin of the Antarctic Peninsula (figure 4-3).[9] The San Jorge Basin contained proven reserves of 1.6 billion barrels in rocks of Jurassic or Early Cretaceus age. Sedimentary rocks of the same age are found in the Larsen Basin, but this in itself does not indicate hydrocarbon potential.

Mossel Bay off southern Africa is a minor petroleum producer. This basin bears a paleogeographic relationship to the Falkland Plateau, but may not be indicative of the hydrocarbon potential of the Weddell embayment.

Minor hydrocarbon accumulations have been found off the east coast of India in the Bay of Bengal and in Upper Cretaceus rocks in the Palk Bay area, which, through reconstruction, could correspond to the Prydz Bay area of Antarctica (Amery Basin) in which Cretaceus sediments have also been identified. The Prydz Bay area may also bear a relationship to the West Australian continental margin where producing fields are found near Perth.

The Cooper Basin in central Australia lies in a broad geologic province that possibly extended southward into Wilkes Land prior to their separation around 80 million years ago.[10] The Cooper Basin is an oil and gas producing province in Permian through Cretaceus rocks. No commercial petroleum discoveries have yet been made in the Great Australian Bight, Eucla, or Duntroon Basins (figure 4-3), which may, in part, be the conjugate margin to the Aurora Basin in the Wilkes Land region of Antarctica. The Otway and Bass Basins of Australia, which in the Gondwana reconstruction extend offshore toward Wilkes Land, are only minor producers.

The Gippsland Basin, in the Bass Strait between Tasmania and Victoria, is a major petroleum-producing province. However, the tectonism that formed the petroleum-bearing structures in this basin is not part of the southern Australian marginal rift system. Because Antarctica and Australia were already separated at the time of formation of the hydrocarbon-bearing structures in the Gippsland Basin, the basin has no analog on the Antarctic margin.[11]

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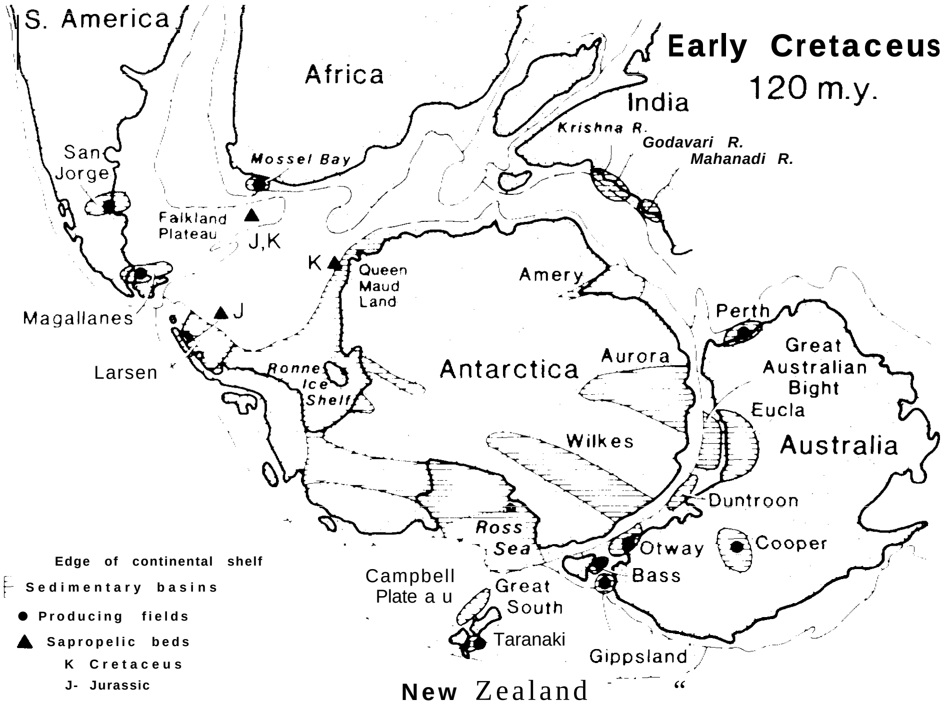
[8] Ibid.

[9] D.H. Elliot, "Antarctica: Is There Any Oil and Natural Gas'?" *Oceanus*, vol. 31, No. 2. Summer 1988, p. 38.

[10] Ibid.

[11] "Are There Petroleum Resources in Antarctica?' Petroleum *and Mineral Resources of Antarctica*, John C. Behrendt (cd.), U.S. Geological Survey Circular 909, 1983, p. 20.

Figure 4-3-Reconstruction of Gondwana in Early Cretaceus Time
(120 Million **Years Ago)**



The proximity of Antarctic sedimentary basins is shown in relation to basins in formerly adjacent continents and to producing 011 and gas fields.

SOURCE D H Elliot, "Antarctica. Is There Any 011 and Natural Gas?" *Oceanus*, VOl 31, No. 2, Summer 1988, p 37

The Campbell Plateau is the conjugate margin to the Ross Sea region, The Taranaki Basin off the North Island of New Zealand is primarily a gas-producing region and probably has no relationship to the Ross Sea continental shelf. Thus, **for the most part, the sedimentary basins on surrounding continents that have analogs in Antarctica are not major petroleum producing provinces.**

ANTARCTICA IN THE CONTEXT OF FUTURE MINERALS SUPPLY

The long-term availability of raw materials has been a recurring concern over much of the past century. This concern attained a new measure of public awareness in the 1970s when the price of oil and other commodities increased sharply. The public quickly realized that certain essential materials may be in finite supply and, hence, would become more costly and difficult to obtain. As a result of these concerns, exploration and exploitation of Antarctic minerals began to be seriously discussed.

Ore deposits form by relatively unusual combinations of natural processes, and, consequently, large, economic deposits are not common in the Earth's crust. For metallic minerals, these processes can be described as falling into three general classes, The two most important are **magmatic differentiation** and deposition from **hydrothermal solutions. Sur**face or near-surface enrichment is the third. Magmatic differentiation is the process whereby the various elements are distributed into the rocks formed during cooling and crystallization of a magma; locally concentrated deposits of certain minerals may be formed, Hydrothermal solutions or hot saline fluids pass through fractures or pore spaces *in rock,* dissolving or dislodging metals that are subsequently redeposited as sulfides, oxides, or even native metal, as the fluids cool or other conditions change. Surface or near-surface enrichment is simply the further concentration of metals by weathering or leaching by groundwater.

An ore deposit represents a special set of geologic circumstances and only becomes an economic proposition if a number of factors are favorable.[12] The first is discovery of the deposit itself. A vigorous exploration program does not automatically lead to the discovery of a new mineral deposit rich enough to mine. In Antarctica, a continent mostly covered by ice, the probability of discovery is greatly diminished.

Finding an ore deposit of sufficiently high grade is not enough. Accessibility is also very important. Deposits found near existing infrastructure will be mined before more remote deposits, other considerations being equal. In Antarctica, there is essentially no infrastructure.

A third factor controlling the development of mineral resources is the size of the deposit. Not only must the deposit be rich, but it must also be large enough to warrant the investment needed to develop it. In general, as the remoteness of the location increases, so must the size of the deposit necessary to offset the costs of the new infrastructure that will be required to develop it. Antarctica is the most remote continent in the world, Consequently, only large deposits, if any, will likely be developed. If first generation development were to occur and an infrastructure created, then costs of development of smaller deposits nearby, if any, may be lowered.

The largest deposits of a specific mineral or minerals are the easiest to find and tend to be discovered first. For any specific metallic resource, the few largest-tonnage deposits contain the majority of the total metal mined. For example, out of 165 porphyry copper deposits, the 16 largest deposits contain 64 percent of the metal content (past production plus resources), and the 82 largest deposits contain 94 percent of the metal.[13] For nickel, only 7 deposits account for more than 50 percent of the metal in a total of 156 nickel deposits; for tungsten, 3 deposits among 32 account for 59 percent of the tungsten; and for molybdenum, 3 of 34 porphyry molybdenum deposits account for 65 percent of the metal. Thus, based on past experience, **if a very large ore deposit were found in Antarctica, it would likely be found in the earlier stages of serious exploration and could, if developed, make a significant contribution to the world inventory of that mineral commodity.**

Much the same case can be made for large petroleum accumulations. A suitable environment had to have been present to have produced organic-rich source sediment. The source beds must have been buried and over time the temperature raised by the flux of geothermal heat (the internal heat of the Earth) to a degree sufficient to maturate the organic material and produce oil. The depth of this time-temperature range in which maximum oil generation occurs is known as the "oil window. ' The oil window generally occurs at depths between 2,500 and 16,000 feet and at temperatures between 150 and 300 "F. Natural gas is formed below the oil window. In areas of higher than normal geothermal heating, the oil window exists at shallower depths, is narrower, and encompasses younger sediments.

Petroleum must be retained in a **structural** or **stratigraphic trap** in order to produce a reservoir and prevent migration to the surface as probably occurred for much of the petroleum that has formed during the Earth's history. In Antarctica, not only must all of these conditions be met, but also **any reservoir will have to be located in an area where production is physically possible, and the field will likely have to be very large to be commercially viable.**

The same two principles that apply to ore bodies apply to world oil distribution as well. First, most oil is contained in a few large fields, but most fields are small. Second, in any region the large fields are usually discovered first. Since exploration for oil began in the early 1860s, some 40,000 oil fields have been discovered worldwide. The two largest classes of fields are the supergiants (fields larger than 5 billion barrels of recoverable oil) and the world-class giants (fields with 500 million to 5 billion barrels of recoverable oil). Only 38 supergiant oil fields have been found worldwide, and these few fields origi-

[12] See, for example, F.E. Trainer, "Potentially Recoverable Resources—How Recoverable'?" *Resources Policy,* March 1982, pp. 41-52.

[13] John H. DeYoung Jr, and Donald A. singer, "Physical Factors That Could Restrict Mineral Supply, ' *Economic Geology, 75th Anniversary* volume, 1981, pp. 942-943.

nally contained more than half of all of the oil discovered thus far. Twenty-six of these supergiants are in the Persian Gulf region, Three are in the Soviet Union; the United States, Mexico, and Libya each have two supergiants; and Algeria, Venezuela, and China have one each. The nearly 300 known world-class giant fields plus the 38 supergiants together account for about 80 percent of the world's discovered recoverable oil. Petroleum experts estimate that there are probably less than ten supergiants remaining to be discovered. **It is probable that nothing smaller than world-class giants or supergiants would be economic in the harsh Antarctic environment.**[14] Because large fields are usually found early (the biggest structures are more easily located and, therefore, are drilled first), it is likely that if any large fields exist in Antarctica, they will be discovered relatively early during exploration drilling.

In Antarctica, even a large field may not in itself be enough. The character of the reservoir is also important. For example, a reservoir will have to be relatively thick so that it can be drained by a minimum number of strategically placed wells. This is because the high cost of drilling and operating in polar regions limits the number of wells and production facilities that a field can support. Consequently, a large field with a relatively thin pay zone spread over a great area, may not be economically producible. Past experience has shown that a relatively small percentage change in world petroleum supply can have a substantially greater effect on the price of oil. Consequently, a relatively small shortage in available petroleum supply can have a magnifying effect on the price of oil and change the economics of field development.

Prospecting and Exploration in Antarctica

Prospecting and exploration in Antarctica would be extremely difficult. Mean air temperatures are much lower than those of any other large area of the Earth's surface, and winds generally are stronger and more constant than elsewhere. prospecting and exploration would likely be conducted only during the summer months. Transportation to most interior locations would likely be by air. This can be hazardous because weather forecasting is not highly developed in Antarctica and adverse weather conditions en route or at the destination may not be known when a flight begins. The logistics of transportation and supply commonly dominate decisions on where field work can be conducted, and areas that might deserve detailed study may not be accessible at times or have to be studied hastily,

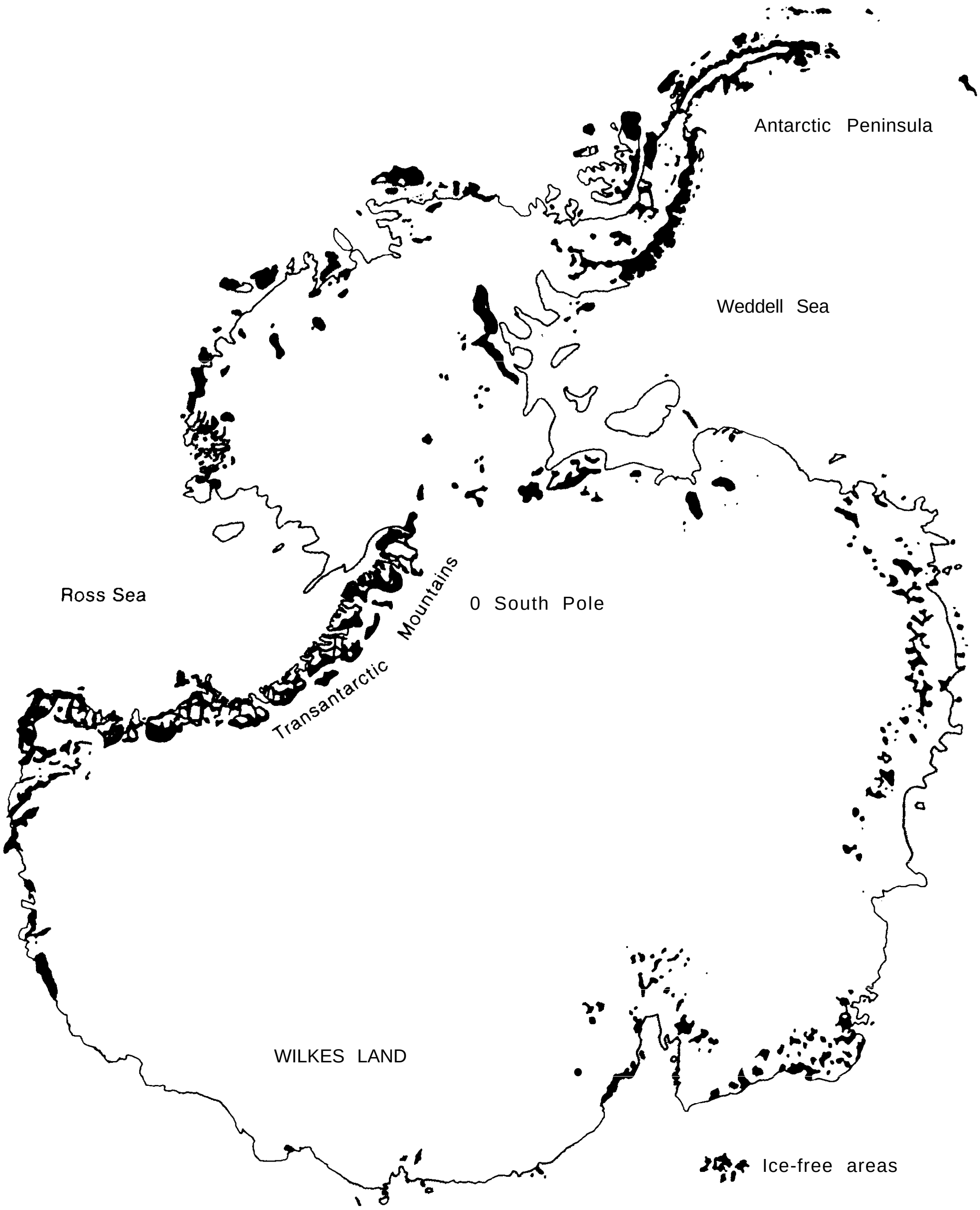
Most geologic investigations conducted thus far have been purely scientific and not designed to explore for and identify mineral deposits. No mineral occurrences have been explored by drilling. The geochemical patterns that result from alteration and mineralization in various areas of Antarctica are virtually unknown. In addition. glaciation could have removed near-surface deposits formed by weathering, and since the onset of glaciation, the ice cover has prevented enrichment processes related to near-surface weathering from occurring. Moreover, there has been little surface drainage during the past 30 million years, thus, the erosion and sorting necessary to form alluvial placer deposits would not have occurred. Older placer deposits, if any exist, would be in stream channels or basins now covered by ice.

Because nearly 98 percent of the continent is covered by ice, few mineral deposits are likely to be exposed (figures 4-4 and 4-5). The total area of exposed rock is comparable in size to the State of Colorado, but it is spread over an area larger than that of the United States and Mexico combined. Therefore, the logistics for any prospecting or exploration program are immense. Most of the exposed areas have been so little studied that they remain among the least geologically and geophysically explored areas of the world. Some large rock outcrops have never been visited.

Offshore, the situation is little better. Although over 54,000 nautical miles of marine multichannel seismic reflection survey lines have been collected around Antarctica since 1976, most of this information has not been published or otherwise made available (figure 4-6). The United States is the only country that has published and made freely available all of its seismic data as required under the Antarctic Treaty. This, however, represents less than 4 percent of the total collected by those conducting research in Antarctica. Very little is openly known about the

[14] "Are There Petroleum Resources in Antarctica? op. Cit., footnote 11, p. 3.

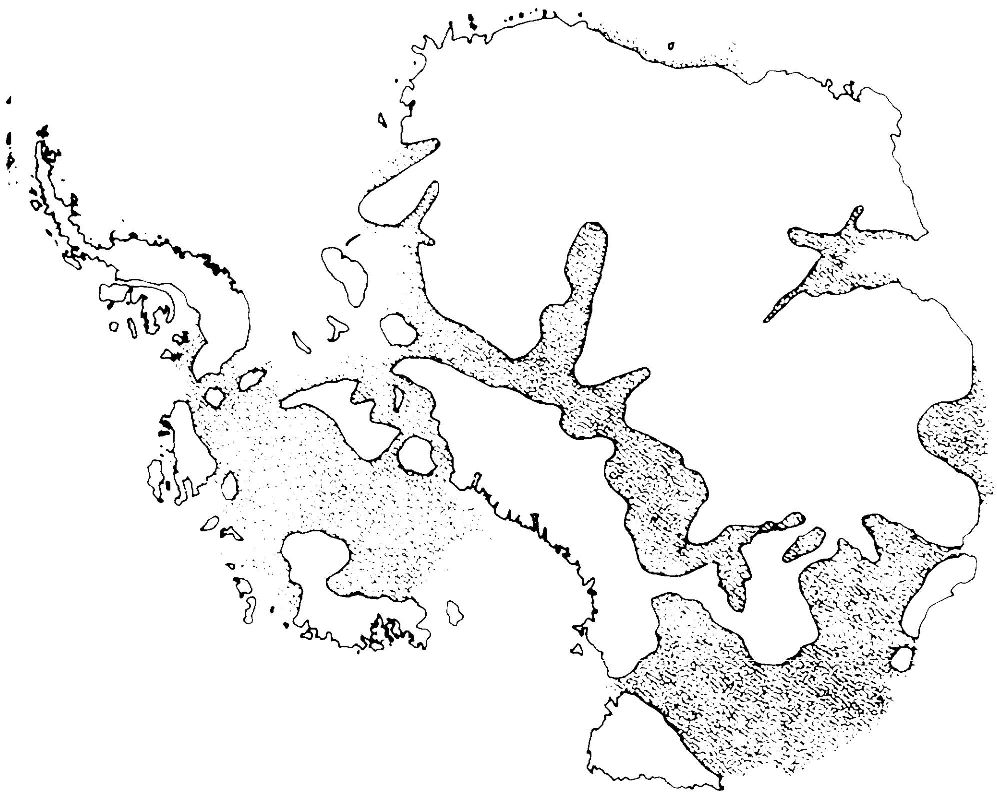
Figure 4-4-Exposed Rock Outcrop In Antarctica



Only *2* percent of Antarctica is exposed. Ninety-eight percent of the continent is covered by a thick ice sheet.

SOURCE: U.S. Gee@@ Survey, 1989

Figure 4-5-What Antarctica Would Look Like If the Ice Ware Removed



SOURCE. Generalized from U.S. Geological Survey, 1989

detailed subsurface structure and petroleum potential of the continental shelf areas. The failure to release data and the fact that many surveys have been run by groups owned in large part by oil companies has led to speculation that much of the offshore geophysical data gathered thus far has been focused on assessing petroleum resource potential rather than acquired for scientific purposes. In any event, the seismic lines run thus far are too widely spaced to be of more than reconnaissance value. Exploration for oil would be conducted on a much tighter grid. However, geological interpretations of the geophysical data can only be verified by drilling into the deeper sediments of each basin.

Five different types of reconnaissance surveys would be desirable to evaluate Antarctica's resource potential. The surveys described below would also provide additional data to supplement ongoing geologic and geophysical research. All the technology required to conduct these surveys is presently available.

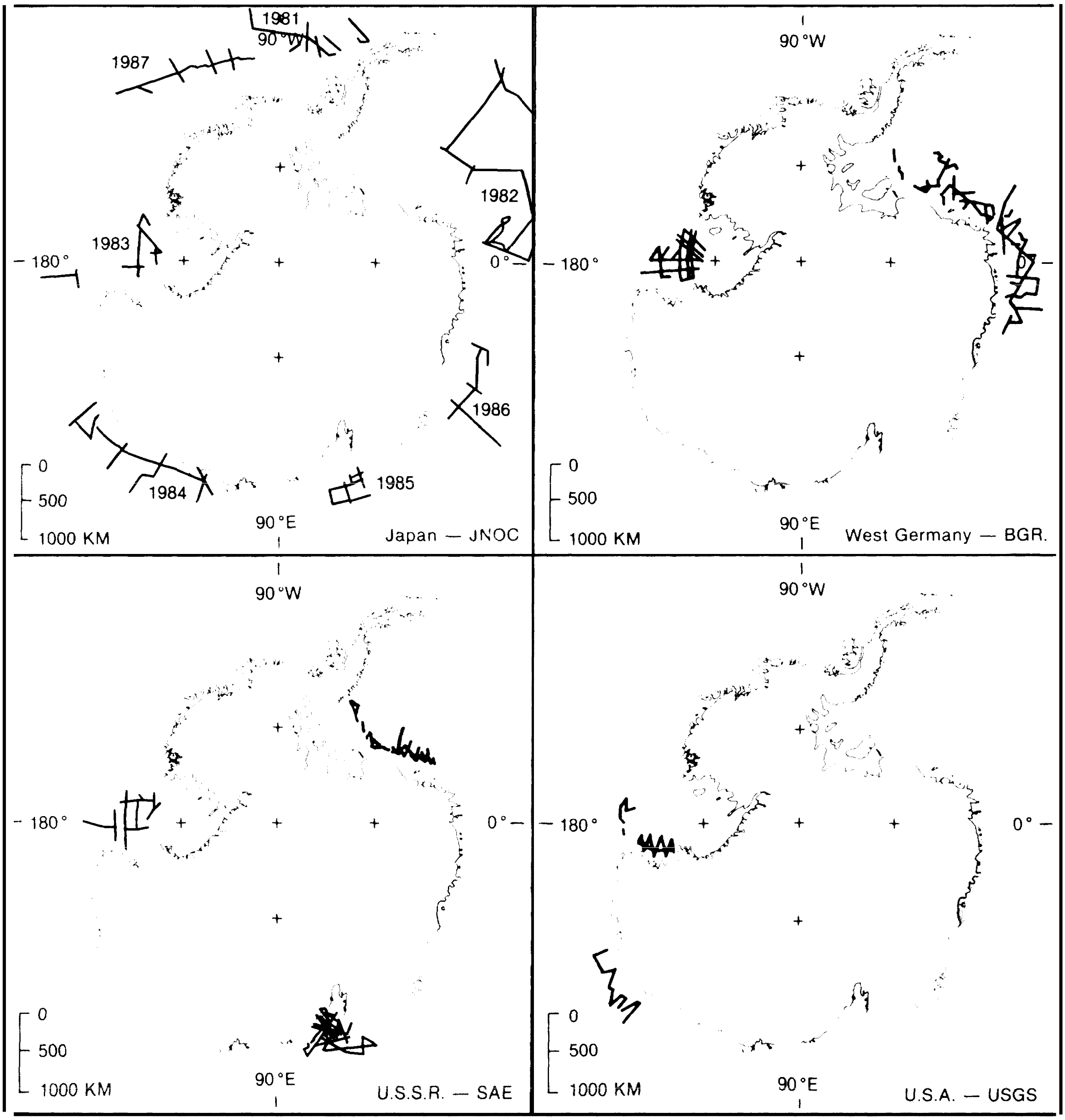
Offshore Geophysical Surveys

There are more than 20 major sedimentary basins and sub-basins on the continental margin around Antarctica. A typical offshore geophysical survey would involve collecting multichannel seismic-reflection data, high resolution seismic-reflection data, bathymetric data, magnetic data, gravity data, and sonobuoy wide-angle seismic data. To date, the small number of U.S. geophysical surveys have focused primarily on the Ross Sea.

Scientific Drilling

Until pre-glacial rock samples are collected from deep within some of the basins surrounding Antarctica, all estimates of hydrocarbon potential must be

Figure 4-6-Multichannel Seismic Data



SOURCE J C Behrendt, U S Geological Survey, 1989 viewed as highly speculative. According to the Minerals Convention, scientific drilling can be carried to any depth. Since 1972, the United States has been involved in 6 major scientific programs, which have drilled holes at more than 50 sites located in and around Antarctica. The greatest advances in our understanding of Antarctic geology over the next decade are likely to come from scientific drilling, if such projects are funded.

Offshore Geohazard Survey

Geohazard studies are critical to understanding geologic processes on the seafloor that could be a hazard to oil recovery structures. Such hazards might include faults, slumps, and significant topographic features. Geohazard surveys typically involve the collection of single channel seismic-reflection data, high resolution seismic-reflection data, precision bathymetric data, multibeam sonar data, seafloor cores and dredge material, and measurements of various sediment characteristics.

Onshore Aerosurveys

Aerosurveys in selected onshore areas of Antarctica have provided the principal information on ice thickness and sub-ice geologic structure. These surveys collect imagery data, such as photographs and radar information, and geophysical data such as magnetic, gravity, and radio echo sounding information. Logistics difficulties, poor navigation, and high costs have limited the quality of past aerosurveys.

Onshore Geophysical Transects

These transects would probably involve the collection of seismic reflection/refraction data and measurements of magnetism and gravity. Newly developed seismic equipment can be rapidly towed across the ice, thereby increasing the amount of data that can be collected over a given period of time.

If the United States decides to fund a comprehensive reconnaissance effort, the United States Geological Survey (USGS) estimates that it would cost about $250 million over a 10-year period (see table 4-1).[15] Some surveys would require all 10 seasons to complete; others only 3 to 5 seasons. Rather than surveying the entire continent, limited areas of the continent (e.g., only the ice-free areas) could be individually surveyed at a lower cost. However, the cumulative cost of many separate and smaller surveys conducted over a longer time period would likely be significantly higher than indicated in table 4-1,

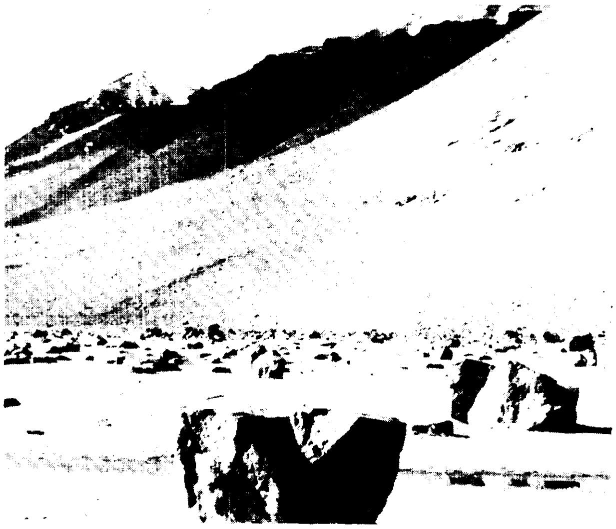


Photo credit: Bill Westermeyer

Don Juan Pond in Wright Valley, one of the "Dry Valleys" near McMurdo.

A similar comprehensive survey is being conducted within the U.S. Exclusive Economic Zone (EEZ), the offshore area within 200 nautical miles of the U.S. coastline. The EEZ was formally established by Presidential proclamation in 1983, thereby giving the United States resource jurisdiction over approximately 2.3 million square nautical miles of largely unexplored territory. This action led to a national effort-jointly conducted by the USGS and the National Oceanic and Atmospheric Administration (NOAA) with additional effort from academic institutions and private industry-to learn more about the geologic framework, seafloor processes, and nonliving resources of the EEZ.[16]

[15] Alan K. Cooper, *Evaluating Antarctica's Hydrocarbon (and Mineral) Potential—Geoscience Data Requirements and Costs,* U.S. Geological Survey, Menlo Park, CA. Special report for U.S. Congress, Office of Technology Assessment, Feb. 21, 1989 (unpublished).

[16] U.S. Congress, Office of Technology Assessment, Marine *Minerals Exploring Our New Ocean Frontier,* OTA-O-342 (Washington, DC: U.S. Government Printing Office, July 1987), p. 3.

Table 4-1-Desirable Research for Evaluating Resource Potential of Antarctica

Type of research	Relative importance for: Oil	Minerals	Estimated 10-yr cost (millions)
Offshore seismic surveys	High	Medium	$ 3 0
Onshore/offshore drilling	High	high	50
Offshore geohazards surveys	Medium	Low	20
Onshore aerosurveys	Medium	Medium	25
Onshore geophysical surveys	Low	Medium	25
Subtotal			1 5 0
Aircraft support			100
Total			$250

SOURCE: *A.* Cooper, U.S. Geological Survey, February 1989

There are important differences between the U.S. EEZ and Antarctica's offshore environment. First, the United States has exclusive rights to develop any resources in its EEZ, whereas U. S.-sponsored Operators would have to compete with others for resource rights in Antarctica. Second, the proximity of the EEZ to the United States simplifies its exploration. Antarctica is more than 10,000 miles from the United States. Finally, the exploitation of at least some of our EEZ resources (e.g., sand and gravel) is likely to be possible in the near future. Exploitation of Antarctica's resources will probably not be seriously considered for a few decades, if at all.

Consequently, **a major effort to undertake a detailed reconnaissance of our own EEZ is more easily justified than a similar effort for Antarctica. However, for the purpose of promoting potential, long-term U.S. commercial interests in Antarctica, a modest reconnaissance program in selected promising areas might be appropriate.** In fact, a fairly good indication of Antarctica's mineral potential could probably be obtained for about half the cost of the comprehensive survey described in table 4-1. Since activity in Antarctica is generally increasing, it may be even more important in the near-term to devote relatively more attention to acquiring baseline environmental data than resource assessment data. Before the recovery of any petroleum resources is attempted, research will be required to ensure that development can be conducted safely and efficiently with a minimum of environmental impacts. Several tens of millions of dollars would probably be required to address the research topics listed in table 4-2 adequately, although a rigorous cost evaluation was not conducted,

Table 4-2-Research Required To Ensure That Petroleum Resources Are Safely and Efficiently Recovered With Minimum Environmental impact

Basic research and information requirements:
- geotechnical studies of continental shelf sediments
- oil spill tracking and cleanup techniques
- improved techniques for forecasting weather, sea state, and pack ice conditions

Research requiring extended time-series measurements:
- circulation patterns and sea ice drift over the continental shelf
- iceberg size, frequency, movement, and scouring of the continental shelf
- adverse short-and long-term effects (e.g., toxicity) of oil dispersants on Antarctic phytoplankton, krill, seals, and benthic communities

SOURCE: Office of Technology Assessment, 1989,

Providing a firm scientific basis on which to estimate Antarctica's mineral resource potential will be a costly venture. These high costs could be reduced considerably through a cooperative international research program sponsored by all parties to the Minerals Convention. Alternatively, different parts of an agreed-upon research program could be conducted by different countries. Industry involvement, although potentially desirable, could complicate the situation somewhat. If such a program were instituted and paid for by private industry, its conduct would then fall under the purview of the Minerals Convention. Industry data could then be considered proprietary for at least 10 years.

Probabilities of Discovering Antarctic Mineral Deposits

A statistical exercise conducted by the U.S. Geological Survey in the early 1970s attempted to estimate the total number of mineral deposits likely to have formed in onshore areas of Antarctica and *the* number of those deposits likely to be discovered.

This exercise apparently has been the only attempt at such a projection.[17] It should be emphasized, however, that it is a paper exercise only and is not tied to an exploration effort.

The USGS began by reconstructing Gondwana and correlating Antarctica's major tectonic belts with the corresponding tectonic belts on the adjacent continents (refer to figure 4-2). Known mineral occurrences in each of the tectonic belts on Gondwana continents adjacent to Antarctica were divided into four categories: (1) **ferrous metals, (2)** base metals, (3) **precious metals,** and **(4)** other deposits (uranium, aluminum, tungsten, asbestos, rare earths, etc.). The density of each type of mineral occurrence in each tectonic belt was calculated. The results were extrapolated to Antarctica to estimate its resource potential in each of the continent's four major geologic provinces (Andean, Ellsworth, Ross, and Antarctic shield). The number of deposits expected in exposed areas in Antarctica was calculated based on the ratio of exposed area to total land area in each province. This number was then further reduced by an assumed success ratio in discovering deposits. These results (without reduction for success in discovery) are given in table 4-3.

Success in discovering mineral deposits in Antarctica is not only a function of the number of deposits expected to exist but also of the intensity of search. For example, the number of precious metal deposits estimated to exist in exposed areas of the Andean erogenic belt in Antarctica is 3.5. Assuming a one percent chance of discovery, the expected number of deposits found on any single exploration attempt would be **0.035** or about three chances in a hundred. Even this may be high for this region.

Again, this exercise is purely an abstract statistical approach and is not based on actual exploration efforts. In addition, what might constitute a commercial deposit elsewhere may not be economically viable in Antarctica. In any event, table 4-3 illustrates that, **other than in the Antarctic Peninsula (Andean Province), the chances of finding mineral deposits in exposed areas are small, and that base metal and precious metal deposits are the best prospects for discovery in the Antarctic Peninsula.**

SELECTED MINERAL RESOURCES

Oil and Gas

Prospects for Antarctica

Sedimentary basins are located on the continental margin of Antarctica and in the interior of West Antarctica. Sediments also probably occur inland of the East Antarctic ice margin (figure 4-7).[18] The major Antarctic basins of interest to petroleum exploration are in the Weddell embayment, Ross embayment, Prydz Bay, and Wilkes Land margin. Other sedimentary basins exist along the East Antarctic margin, the west coast of the Antarctic Peninsula, and probably on the broad continental shelves of the Amundsen and Bellingshausen Seas off West Antarctica. **Offshore sedimentary basins hold the best prospects for petroleum exploration because of the character and thickness of sediments and access for seismic exploration.**

Based on seismic evidence and the results of the Ocean Drilling Program's (ODP) Leg 113, the Weddell embayment contains possibly as much as 46,000 feet of sediment. Other than for the margin of the Larsen Basin and off Queen Maud Land, virtually nothing is known of the age and nature of the sediments. The older strata probably date back to the early stages of formation of the basin in the Late Jurassic period (around 150 million years ago), and consist of terrestrial and marine sediments. These deposits might have contained organic material that could have provided potential hydrocarbon source rocks. These beds are overlain by as much as 10,000 feet of glacially derived sediment, laid down over the last 30 million years, with no source rock potential. The thermal history is unknown, but the oil window has been estimated to lie within the deeper parts of the basins. The Larsen Basin, in particular. on the western side of the Weddell embayment, is estimated to have a moderate potential for hydrocarbon formation. To the east, off Queen Maud Land, the oil window is estimated to lie below the organic-rich beds on the continental shelf.

[17] Wright and Williams, op. cit., footnote 4, pp. 24-27.

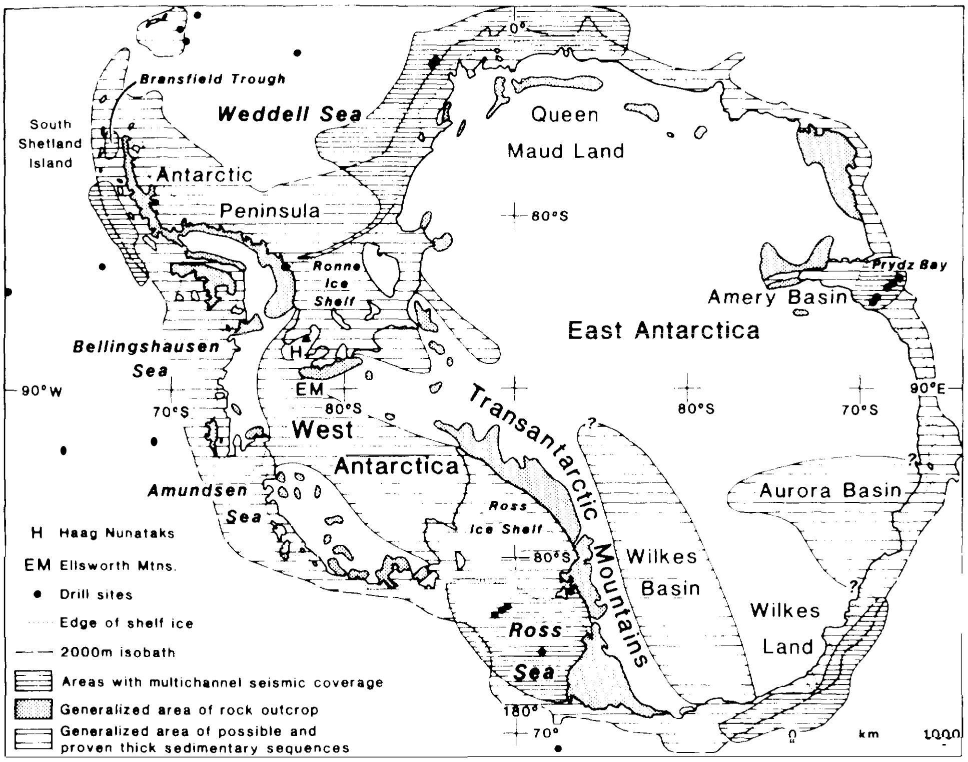
[18] Elliot, op. cit., footnote 9, p. 33.

Table 4-3-Estimated Number of Major Mineral Deposits in Antarctica

Geologic province	Type of deposit: Base metal	Ferrous	Precious	Other
Andean:				
Total	175	60	82	63
In exposed areas	7.5	2.5	3.5	2.5
Ellsworth:				
Total	56	90	8	16
In exposed areas	0.7	1.0	0.1	0.2
Ross:				
Total	10	10	5	8
In exposed areas	0.6	0.6	0.3	0.5
Shield:				
Total	69	138	66	73
In exposed areas	0.1	0.3	0.1	0.1

SOURCE: N.A. Wright and P.L. Williams, "Mineral Resources of Antarctica," US. Geological Survey Circular 705, 1974, pp. 24-27.

Figure 4-7-Sedimentary Basins in Antarctica



The major Antarctic basins of interest to petroleum exploration are in the Weddell embayment, Ross embayment, Prydz Bay, and Wilkes Land margin.

SOURCE: D.H. Elliot, "Antarctica: is There Any 011 and Natural Gas?" *Oceanus,* VOI 31, No. 2, Summer 1988, p. 33.

If this is the case, there would be little potential for petroleum formation in the Queen Maud Land margin.

The Ross embayment contains three identified basins of which the Victoria Land Basin off Ross Island would appear to have the best prospects for petroleum formation. This basin contains as much as 46,000 feet of sediment in a rift zone that has relatively high heat flow. Heavy hydrocarbon residues were recovered from a scientific drill site on the western margin of the Victoria Land Basin in 1986. The asphaltic residue indicates that hydrocarbons formed in the area but have migrated, possibly millions of years ago. Of the other two basins, the Central Trough and Eastern Basin off Marie Byrd Land, only the deepest portions would lie within the oil window. Drill cores from both of these basins have shown traces of gaseous hydrocarbons, but these are from glacial marine sediments and most likely represent local decomposition of organic material not related to the formation of petroleum.

Another rift zone in Prydz Bay, called the Amery Basin, also contains as much as 46,000 feet of sedimentary rock. Cores taken in this area have likewise shown traces of gas. Of more significance geologically is the recovery of Cretaceus sediment, indicating a long history of deposition in preglacial times and, consequently, the possibility of suitable source rock.

The Wilkes Basin is a marine basin extending inland under the ice and offshore onto the continental shelf. This basin contains as much as 20,000 feet of sediment on the shelf including organic-rich material of Early Cretaceus age with source rock potential.

The other sedimentary basins are less prospective for hydrocarbon accumulation. This includes the Brartsfield Trough off the western tip of the Antarctic Peninsula, where hydrocarbons were found in relatively shallow cores from a young (2 million years) and thin sedimentary sequence. While the thermal gradient is sufficiently high in this area to maturate organic material at shallow depth, the thin sedimentary section argues against the likelihood of significant hydrocarbon accumulations. Consequently, it might be presumed that the hydrocarbons being formed in this basin are probably seeping onto the sea floor where they are being degraded by natural processes.

World Resources

Current annual world crude oil production is around 21 billion barrels and has been fairly stable at about that amount for several years. Oil is produced by many countries. The three largest producers, the Soviet Union, the United States, and Saudi Arabia, account for nearly half of annual world production. Until 1987 world proven recoverable reserves were calculated at about 657 billion barrels. Since then, revised estimates, largely of Middle East reserves, have raised this figure to 956 billion barrels.[19] Based on the 956 billion barrel figure the average world reserves to production ratio is 46. Undiscovered recoverable reserves of conventional crude oil are estimated at around 400 billion barrels.

If the remaining recoverable, conventional oil in the world were distributed evenly and exploration and development proceeded at past rates, world oil production could be sustained for nearly 50 years before being constrained by a declining resource base. A steep drop in world oil production of more than 50 percent in 10 years would then be likely.[20] At that time, if not before for other reasons (and demand were still high), oil prices could be expected to rise sharply. If a commercial oil field is discovered in Antarctica in the future, OTA's analysis (app. A) indicates that it will only be developed profitably if oil prices are much higher than today. However, higher oil prices tend to decrease demand and to encourage additional conservation and the use of alternative fuels, Environmental concerns about the burning of fossil fuels, such as ozone depletion and climate change, may also reduce petroleum consumption and hold prices lower.

Discussion of declining conventional petroleum reserves invariably raises the question of the potential for developing unconventional sources of crude oil, namely by developing heavy oil, tar sands, and shale oil, and by using enhanced oil recovery techniques. While some unconventional deposits are being produced today, the annual amount of petroleum derived from them is currently relatively insignificant compared to world consumption: high

[19] Since proved reserves are part of the equation used by OPEC in determining production quotas (a contentious matter), there is some question as to the technical basis for some of the new estimates.

[20] Joseph P. Riva Jr., *The World's Conventional Oil Production Capability Projected Into the Future by Country*, Congressional Research Service, Report for Congress, No. 87-414 SPR, May 1987, p. 15.

rates of production cannot yet be achieved. In addition, current production from unconventional sources is largely from sites with the most favorable characteristics, as would be expected. Projecting significantly greater production from unconventional sources through future technological developments is much easier to envision than accomplish. Consequently, **as long as the world is dependent on petroleum there will be an incentive to locate and produce conventional deposits.**

A decision to develop a promising Antarctic discovery could be made even if development would not be profitable. In particular, it is sometimes suggested that energy-poor countries, such as Japan, may wish to undertake unprofitable development to obtain an assured source of supply. OTA does not think that this motivation is as strong as the profit motive, in part because energy-poor countries have less expensive or less technologically challenging alternatives available to them (e.g., Brazil's sugar cane to ethanol program), and these alternatives are likely to become more diverse and more available in the future as the price of oil rises. Also, Antarctica would not likely be the most secure source of supply in times of emergency.

Energy security is of sufficient concern to the United States that the Strategic Petroleum Reserve (SPR) was created to provide an emergency supply of petroleum in the event of a disruption in imports. At present the SPR contains about 550 million barrels of oil held in caverns leached from salt domes in the Gulf Coast.

As for the possibility that an Antarctic claimant country might try to develop an unprofitable oil field to solidify a claim, neither the Antarctic Treaty nor the Minerals Convention would support this. Even if these agreements were disregarded, a claimant could undertake other, less expensive activities to have the same practical effect.

Although petroleum development in Antarctica is considered unlikely in the near term, OTA has developed a hypothetical scenario for oil field development there. This scenario (found in app. A) explores technology capabilities and needs, addresses economic considerations, and presents several alternative approaches to development.

Coal

Prospects for Antarctica

Coal is found principally in Permian and Triassic rocks around the perimeter of East Antarctica. Thick beds are most notably in the Beacon Supergroup of the Transantarctic Mountains and in the Beaver Lake area of the Prince Charles Mountains. The deposits all seem to have formed on flood plains in shallow swamps that were rapidly being filled with sandy material. Most of the coal deposits are in a Permian sandstone sequence that is more than 1,600 feet thick and found in both the Prince Charles and Transantarctic Mountains. Although individual coal beds as much as 20 feet thick have been reported, most of the beds are less than 12 feet thick and tend to be lens shaped and have a limited horizontal extent. While some coal seams have been traced over a considerable distance, the horizontal extent of most of the individual beds that have been reported is less than half a mile,

The coal is commonly of a high rank, ranging from medium-volatile bituminous to anthracite and generally having a high ash and low sulfur content. Most of the coal occurs in mountainous areas at a considerable distance from the coast. None of the known deposits are economically minable. Deposits near coastal areas would have the greatest potential for export. The conventional wisdom has generally been that while Antarctic coal may not be economic to export, it could possibly be used for local heating or power production. However, even the Soviet station at Beaver Lake, adjacent to exposed coal in the Prince Charles Mountains, finds it more economical to meet energy needs with imported oil.

World Resources

World hard coal (anthracite and bituminous) production in 1987 was nearly 3,6 billion short tons. Although coal is mined in a large number of countries, the three largest producers are China, the United States, and the Soviet Union. Recoverable reserves total 719 billion short tons. The reserves to production ratio is 200. In addition, there are 300 billion tons of recoverable reserves of lignite. **It is highly unlikely that an export market for Antarctic coal would develop in the foreseeable future.**

Uranium

Prospects for Antarctica

Uranium occurs in many geologic settings. Among the more important categories are quartz-pebble conglomerate deposits, deposits related to erosional surfaces in Precambrian rocks, disseminated and contact deposits in igneous and metamorphic rocks, vein deposits, and sandstone deposits of various ages. Again, some insight can be gained by comparing Antarctica with the surrounding Gondwana continents. South Africa contains an abundance of uranium and is a major uranium producer. However, most of the uranium produced in South Africa is a byproduct of gold mining, principally from the Precambrian quartz-pebble gold conglomerates of the Witwatersrand region. Australia is also a major uranium producer. In Australia, most of the known uranium resources are contained in deposits spatially related to erosional surfaces in Precambrian rocks. The South African and Australian deposits suggest that uranium might be present in the Precambrian rocks of East Antarctica.

Uranium minerals, or anomalous levels of radioactivity, have been found in several locations in Antarctica, particularly in Enderby Land, the Adelie Coast, and the Transantarctic Mountains of Victoria Land in East Antarctica. No **known occurrences of radioactive minerals in Antarctica contain commercial quantities.** However, larger deposits might be present in sedimentary basins that existed prior to the break up of Gondwana.

World Resources

Reported world uranium production in 1986 totaled 40,900 short tons. Reactor requirements were 43,200 short tons with the difference being made up from stocks. Exclusive of China, Eastern Europe, and the Soviet Union for which data are not available, the four largest producers were Canada, the United States, South Africa, and Australia followed by Namibia, Niger, and France. Total known resources, which include the reasonably assured resources and the estimated additional resources based on direct geological evidence, total 3.9 million tons. The ratio of known resources to reactor requirements currently stands at 91 or nearly a century of supply. In addition, undiscovered resources are estimated at over 1.8 million tons. **Even with the projected moderate growth in nuclear power production, supplies of uranium should be adequate for the foreseeable future.** In the long term, advances in nuclear power generation and enrichment technologies are expected to reduce the requirements for natural uranium. Even though the cost of uranium in current prices may be higher in the long term, the cost of finding and producing uranium from Antarctica would likely be much higher still.

Chromium

Prospects for Antarctica

Of the many minerals that contain chromium, the only ore mineral is chromite, an oxide of chromium and iron. Primary chromite deposits occur as stratiform or **podiform** bodies in certain types of **ultramafic** rocks composed primarily of olivine and pyroxene minerals, or rocks derived from them. Chromite is also found in placer deposits derived from the weathering of primary deposits. Stratiform chromite deposits are found in layers of up to several feet thick of fairly uniform composition extending over large areas. The Bushveld Complex in the Republic of South Africa and the Stillwater Complex in Montana are deposits of this type. Most of the world's identified chromium resources are in stratiform deposits. Podiform deposits are generally smaller and, as implied by the name. the ore is in irregular pods or lenses within the host rock.

The Dufek intrusion in the northern Pensacola Mountains of the Transantarctic Mountain chain is a very large stratiform body with a composition similar to that of the Bushveld and Stillwater Complexes. While concentrations of minerals containing chromium have not been found in the Dufek, anomalous trace amounts of chromium, nickel, and cobalt have been reported in some of the rock analyses. Consequently, there is speculation based on geochemical comparisons and interpretation that the Dufek intrusion may contain significant amounts of chromium, nickel, and platinum-group metals in the lower unexposed portions. Chromite has also been found disseminated and in thin layers in a small ultramafic intrusion on Gibbs Island in the South Shetland Islands. In addition to chromium, the intrusion may also contain nickel and cobalt minerals, However, the chromite occurrence does not appear to have commercial potential.[21]

World Resources

Chromium has important uses in the metallurgical industry to enhance such properties as hardenability, impact strength, and resistance to corrosion, oxidation, and wear. Ferrous alloy production, mainly stainless steels, accounts for most of the chromium consumed. Chromium also has uses in refractory materials and chemical products. Chromium is considered a strategic and critical material for National Defense Stockpile purposes; several forms of chromium-bearing materials are contained within the stockpile.

World mine production of chromite in 1988 was 12.4 million short tons. The Republic of South Africa and the Soviet Union each produced nearly one-third of the total. The world reserve base of chromite is 7.5 billion tons of which 84 percent is in South Africa and 11 percent is in Zimbabwe. The reserve base to production ratio is 658. World resources total about 36 billion tons of chromite, of which over 99 percent is in southern Africa. In summary, there is enough chromium in known deposits to last for centuries, although the fact that most of it is concentrated in one region may be of concern. **At current prices in South Africa of about $56 per ton, it would hardly be economic to develop a chromite deposit anywhere except under special circumstances.** However, if the circumstances included a complete cut off in supply from South Africa over a long term, the economics of the world market would certainly change. The economics of a chromite mining operation in Antarctica could also improve if there were associated coproducts of higher value such as platinum or cobalt. In addition, a strategic rather than an economic incentive could drive interest in prospecting for chromium in Antarctica.

The difficulties of hard rock mining in Antarctica are discussed in appendix B with regard to both an inland location such as the Dufek Mass if and at a more accessible coastal location. Because the ore, type, and location of any hypothetical mine site are so completely speculative, and because there are too many other variables, at present, it was not considered possible to develop a specific scenario for hard rock mining that would provide any additional insight. However, by comparison with selected hard minerals mines in the Arctic, some speculative estimates can be made of technological problems and ore values needed for a commercial Antarctic mine.

Copper

Prospects for Antarctica

Although copper is found in several types of deposits including porphyry, sedimentary, and volcanic, porphyry copper deposits include the largest known deposits and make up 52 percent of the world resources of the metal. Many of the more important porphyry copper deposits also contain commercially important quantities of molybdenum, while others contain gold and silver. Most copper occurrences in Antarctica have been found in the Antarctic Peninsula and on islands off the coast of the Peninsula. The most promising copper occurrences are on islands off the west coast of the Peninsula and are associated with the youngest intrusions of the Andean belt. Economically promising deposits, if any are found in this region, would likely be of the type found in porphyritic igneous rock and may be associated with possible vein deposits. Veins containing a variety of metals are found throughout the Antarctic Peninsula.

Extensive products of mineralization on King George Island, including pyrite, hydrothermally altered rock, and large veins have led some investigators to speculate that there maybe a porphyry-type copper deposit at depth on King George Island. The hydrothermally altered rocks containing mineralization are interpreted as representing the upper or near-surface portion of a large intrusive body. In addition, the pyrite contains anomalously high copper and cobalt values, suggesting that the intrusive body may be rich in copper. Others, however, do not find the evidence for an underlying porphyry copper deposit compelling, and they suggest that the observed minerals represent normal separation during solidification of an intrusive body of this sort.

[21] Rowley et al., op. cit., footnote 3, p. 40

Other copper occurrences have been reported in the South Shetland Islands. Two localities on Livingston Island contain copper associated with igneous intrusive bodies. In one place, the copper minerals may represent the remains of a deeply eroded copper-molybdenum porphyry deposit, Vein and porphyry-type alteration and mineralization took place on a number of other islands and coastal locations throughout the region. Copper occurrences are found in about 30 places along the east coast of the Antarctic Peninsula. Low grade porphyry copper and vein deposits also are found in the southern part of the Peninsula. Three locations, in particular, contain porphyry copper mineralization. One is a low grade copper-molybdenum deposit in the Copper Nunataks of the central Lassiter Coast. Another is in the Sky-Hi Nunataks, and the third is in the Merrick Mountains of eastern Ellsworth Land. Minor amounts of copper minerals have also been found in some of the metamorphic and intrusive rocks of East Antarctica and the Transantarctic Mountains. Sedimentary rock units of the Transantarctic Mountains could also be prospective hosts for stratiform copper deposits.

World Resources

Copper has been one of the more important materials in the advance of industry, technology, and the arts. The largest use of copper is in electrical applications such as motors, generators, power distribution facilities, industrial controls, communications equipment, and wiring. The U.S. Government Stockpile goal for copper is 1 million tons, whereas the inventory is 22,000 tons.

World mine production of copper in 1988 totaled 9.4 million short tons of recoverable copper metal. Chile and the United States were the two major producing countries, with other major producers including Canada, the Soviet Union, Zaire, Zambia, Poland, and Peru. The world reserve base of copper is about 620 million short tons of recoverable copper, of which Chile and the United States together have nearly 40 percent. The ratio of world reserve base to production is 66. Land-based world resources are estimated at 1.8 billion tons of copper, and resources in deep sea nodules are estimated at 0.8 billion tons, **In view of the relative abundance of copper resources, there would appear to be little economic incentive to extract copper from Antarctica, given the added costs of operating in such an environment, unless it were an exceedingly rich and accessible deposit.** Porphyry copper deposits are typically low grade, high volume ore bodies. Any associated coproducts such as precious metals (gold, silver, and platinum), molybdenum or other base metals (lead and zinc), or cobalt could improve the economics.

Gold

Prospects for Antarctica

Gold is found as a trace mineral in certain course sediments, and in a series of deposits of deep-seated origin that are somewhat difficult to classify. Gold occurs widely in gravels as a placer deposit. Typically, these are fluviatile deposits near the headwaters of fast-flowing rivers where gold particles are trapped between pebbles or in bedrock irregularities. In Antarctica, placer deposits could only have occurred before the onset of glaciation and would now probably be buried under ice. The gold deposits of the Witwatersrand in South Africa occur in Precambrian conglomerate. This may suggest that similar deposits could exist in the Precambrian shield of East Antarctica, although they would probably need to be of higher grade to be economic in Antarctica.

Other types of gold deposits are associated with magmatic, hydrothermal, or metamorphic activity. For example, gold is commonly found in quartz veins and related deposits cutting through a variety of host rocks. In continental tectonic belts, gold deposits are found that are broadly related to the hydrothermal phases of calc-alkaline and **alkaline** igneous rocks. In hydrothermal deposits, metallic minerals are precipitated from high-temperature aqueous solutions, either by changes in temperature and pressure or by evaporation of the liquid. Minerals are deposited in the cavities, cracks, or interstices of the host rock. Many porphyry copper deposits contain important amounts of gold, and many have an alluvial dispersion of gold around their outcrops. While gold could occur throughout many regions of Antarctica, perhaps the most promising region for its discovery and possible development might be the Antarctic extension of the Andean magmatic and reformational belt. This region includes the Antarctic Peninsula and the coastal regions of Ellsworth and Marie Byrd Land. Although the Antarctic Peninsula may be less metal rich, this belt in the northern and central Andes is one of the richest metal-producing areas in the world. The volcanic and intrusive rocks of the Antarctic Peninsula belong to the calc-alkaline magmatic suite with which many of the world's copper-lead-zinc and similar ores, often containing silver and gold, are associated. In addition, the Antarctic Peninsula and nearby islands are the most ice-free and accessible region in Antarctica, thus, making both mineral discovery and potential development more feasible.

No significant concentrations of gold have been recorded in Antarctica. Minor gold and silver have been reported in assays of sulfide minerals from several locations in the Antarctic Peninsula region, Traces of gold and silver have also been found in the Cape Denisen area of the Adelie Coast and in Victoria Land,

World Resources

In 1988, world mine production of gold reached 55 million troy ounces valued at about $24 billion. About 35 percent of this production came from the Republic of South Africa. The next largest producers in decreasing order were the Soviet Union, the United States, Australia, and Canada. The world reserve base is over 1.5 billion ounces of which more than half is in the Republic of South Africa. The reserve base to production ratio is over 28. The world's gold stocks, excluding gold in industrial usage, total about 2.7 billion ounces, of which 1.23 billion ounces are official monetary stocks and 1.44 billion ounces are privately held as coin, bullion, or jewelry. Total world resources of gold are estimated at 2.4 billion ounces, of which 15 to 20 percent are byproduct resources. The Republic of South Africa has about one-half of the world resources, and the Soviet Union, Brazil, and the United States about 12 percent each. **At current world market prices, if a rich gold deposit were discovered in Antarctica, particularly in the region of the Antarctic Peninsula, there would likely be economic interest in considering its extraction.**

Iron

Prospects for Antarctica

Iron is the fourth most abundant rock-forming element, chemically making up about 5 percent of the Earth's crust. The largest concentrations of iron are found in banded sedimentary iron formations of Precambrian age. These formations supply most of the world's iron ore and comprise the bulk of the world's iron resources. The most extensive iron deposits in Antarctica are in East Antarctica, where a Precambrian banded iron-formation (jaspilite), similar to the Lake Superior-type ores, is found. The largest of these deposits is in the Prince Charles Mountains, notably at Mount Rucker, where individual jaspilite beds up to 230 feet thick alternate with slate, siltstone, ferruginous quartzite, schist, and metamorphosed igneous rocks. In addition, although not exposed in outcrop, large magnetic anomalies, some extending for over 100 miles under the ice, almost certainly indicate additional iron deposits. In general, scattered exposures of bedrock and glacially transported boulders indicate that iron formations occur between western Wilkes Land and western Enderby Land, covering a large area of East Antarctica.

Based on their limited exposure, the Mount Rucker deposits appear to be of lesser grade than commercial banded iron-formation elsewhere in the world, except for deposits near industrialized areas. The average iron content is 34 percent whereas, for example, the Hammersley Basin deposits of northwestern Australia contain huge reserves averaging around 55 percent iron. For this reason and because the Mount Rucker deposits are nearly 400 miles from the coast, it is highly unlikely that they will become economically developed.

An iron oxide vein subprovince occurs in western and central Queen Maud Land where quartz-magnetite and garnet-magnetite veins from 2 to 15 feet wide are found in gneissic country rock at the contacts with mafic intrusions. Numerous iron occurrences are found throughout the region in veins and stockworks of various ages, some associated with copper and other metals.[22]

[22] P.D. Rowley, A.B. Ford, P.L. Williams, and D.E. Pride, "Metatlogenic provinces of Antarctica,' *Antarctic Earth Science*, R.L. Oliver, P.R. James, and J.B. Jago (eds.) (Cambridge, MA: Cambridge University Press, 1983), p. 416.

World Resources

World mine production of iron ore in 1988 was 918 million long tons. The two countries producing the largest amount were Brazil and the Soviet Union. The world reserve base of iron ore is estimated at213 billion long tons, of which approximately one-fourth is located in the Soviet Union and one-fifth in Australia. Large amounts are also found in Brazil, Canada, India, South Africa, and the United States. The reserve base to production ratio is 245. Consequently, at the current annual rate of production, the reserve base would last nearly two and one-half centuries. Furthermore, world resources are estimated to exceed 800 billion long tons. Thus, **it is reasonable to conclude that there will be no market for Antarctic iron ore in the foreseeable future.**

Molybdenum

Prospects for Antarctica

Most molybdenum deposits are of three major types:

- porphyry or disseminated deposits, including stockworks and breccia pipes, in which metallic sulfides are dispersed through relatively large volumes of altered and fractured rock,
- contact-metamorphic zones and bodies of silicified limestone adjacent to intrusive granitic rocks, and
- quartz veins.

All three of these types are hydrothermal in origin and represent nearly all of the molybdenum mined in the world. In addition to the porphyry deposits in which molybdenum occurs as the principal metal sulfide, many porphyry copper deposits contain smaller amounts of molybdenum as an important byproduct. In Antarctica, molybdenum is found associated with copper mineralization in the Antarctic Peninsula region. In addition, molybdenum minerals are widespread in dikes and pegmatites in Wilkes Land in East Antarctica and at a number of localities along the Adelie Coast. None of these occurrences is of economic significance. The best prospect for locating a significant molybdenum deposit in Antarctica would likely be in association with a copper porphyry in the Antarctic Peninsula region.

World Resources

Molybdenum is a refractory metallic element used primarily as an alloying agent in steels, cast irons, and superalloys to enhance hardenability, strength, toughness, and resistance to wear and corrosion. Mine production was 189 million pounds of recoverable molybdenum metal in 1988 of which the United States produced over 39 percent. Other major producers were Chile, Canada, Mexico, and Peru. The reserve base to production ratio for molybdenum is 145 or enough to maintain production at current levels well into the 22nd century. Over 45 percent of the world's reserve base is located in the United States. Identified resources amount to about 46 billion pounds worldwide. Molybdenum resources are adequate to supply world needs for the foreseeable future. It **is difficult to envision a situation wherein a molybdenum mining operation in Antarctica could compete in the world market for quite some time without additional revenues from associated coproducts.**

Platinum-Group Metals

Prospects for Antarctica

The platinum-group metals are geochemically associated with mafic or ultramafic rocks and occur as segregations in layers or pods, Because of their relatively high specific gravity, platinum-group metals also are found in placer deposits sometimes associated with gold. The world's premier platinum deposit is the layered lode deposit in the Merensky Reef of the Bushveld complex in the Republic of South Africa. Although much younger than the Bushveld complex, the Dufek intrusion in the northern Pensacola Mountains of Antarctica is a similar layered mafic igneous complex of considerable extent. It approaches the Bushveld complex in size and is an order of magnitude larger than any other known body of this type. The great size of the Dufek intrusion and its similarity to other mafic igneous intrusions, nearly all major examples of which contain economically significant resources of one or more metals, has prompted considerable speculation regarding its mineral potential.[23]

Comparison to the Bushveld and other similar intrusions suggests that if the Dufek contains significant quantities of platinum-group metals, they

[23] Maarten de Wit, *Minerals and Mining in Antarctica* (Oxford: Clarendon Pros, 1985).

likely would be within the unexposed basal parts. To date, no platinum-group minerals have been identified in the Dufek intrusion, although some rock analyses have shown trace amounts of these elements. The extent to which age is a factor in assessing the mineral potential of the Dufek intrusion is unknown. Most other stratiform mafic intrusions containing economically significant resources are Precambrian in age, whereas the Dufek intrusion is Jurassic. Another consideration that would affect the economics of developing a mineral deposit in the Dufek intrusion is the fact that the exposed portions, which represent only a few percent of the intrusion, are more than 300 miles from the ocean. Based on geophysical evidence, the intrusion itself is believed to extend out under the Filchner and Ronne Ice Shelves.

World Resources

The uses of the platinum-group metals are related to their chemical inertness over wide temperature ranges, excellent catalytic qualities, and high melting points. Three of the group, platinum, palladium, and iridium, are considered strategic and critical for purposes of the National Defense Stockpile. The stockpile inventory of each, however, is less than half the desired goal.

World mine production of platinum, palladium, iridium, osmium, rhodium, and ruthenium together totalled over 8.9 million troy ounces in 1988. The major producer countries are the Republic of South Africa and the Soviet Union. The world reserve base of platinum-group metals is estimated to be 2.14 billion troy ounces of which 1.9 billion ounces (89 percent) are in South Africa. The ratio of world reserve base to production is 268 or enough to last over two and one-half centuries at current production rates. World resources of platinum-group metals are estimated to be 3.3 billion ounces of which the United States holds about 300 million ounces. **Considering the difficulties of mining in the interior of Antarctica, unless there were a major disruption of supplies from South Africa there would probably be little economic incentive to develop a platinum deposit in Antarctica if one were found. The** deposit would have to be exceedingly rich to provide an economic incentive.

Strategic and critical mineral concerns could provide sufficient incentive to develop a platinum-group metals deposit in Antarctica, even if it were not commercially viable. On the other hand, new developments in catalysts that could replace platinum-group metals could reduce critical mineral concerns.[24]

Rare-Earth Metals

Prospects for Antarctica

The rare-earth elements, sometimes called the lanthnides, are a group of 15 chemically similar elements with atomic numbers 57 through 71, inclusive. Although not a lanthanide, yttrium, atomic number 39, is often included with the rare-earth metals because it commonly occurs with them in nature, having similar chemical properties. Some members of the rare-earth group of metals are relatively abundant in the Earth's crust, such as cerium, neodymium, lanthanum, and yttrium, whereas others are considered rare. The rare-earth elements and yttrium are minor constituents in over 100 minerals, but in only a few are they sufficiently concentrated to be considered ore minerals. The two minerals that are the primary sources of rare-earth elements are bastnasite and monazite of which bastnasite is the major source. These minerals generally occur in granitic rocks more commonly than in basic rocks, Monazite is genera1ly recovered from beach sand deposits as a byproduct of other heavy minerals recovery such as ilmenite, rutile, zircon, and gold. Xenotime is a yttrium phosphate mineral found in the same environment as monazite, and is a major source of yttrium.

In Antarctica, airborne radiometric surveys have found radioactivity anomalies that have been shown, on field inspection, to be related to thorium- and uranium-bearing minerals as well as to rare-earth and tin-bearing minerals within sandstone of the basal (Devonian) parts of the Beacon Supergroup in the Darwin Glacier area of the Transantarctic Mountains.[25] Upper Permian or Triassic nepheline syenite plutons in western Queen Maud Land of East Antarctica contain zirconium and the rare-earth elements, lanthanum and cerium,

[24] Recently Ford Motor Co. announced that it has discovered a potential substitute for platinum used in catalytic converters.

[25] Rowley et al., op. cit, footnote 7.

Box 4-C—Icebergs (Fresh Water)

Although, technically, ice is a mineral resource there was agreement among the Consultative Parties that the definition of mineral resources in article 1 (6) of the Convention (defined as nonliving, natural, nonrenewable resources) does not include ice. During the negotiation of the Minerals Convention, there was a specific decision to exclude ice from coverage of the minerals regime. The Final Act of the Special Consultative Meeting notes that harvesting ice from the coastal region of Antarctica, particularly if land-based facilities were required, could raise some of the environmental and other issues addressed in the Convention. Consequently, representatives at the meeting agreed that the question of harvesting Antarctic ice should be further considered by the Consultative Parties at the next regular meeting.

It is estimated that Antarctica contains over 90 percent of the world's fresh water in the form of ice and snow that accumulated over millions of years. [1] Precipitation in most of Antarctica is very light. Annual snowfall at the South Pole is less than an inch water equivalent, making it drier than some desert areas elsewhere in the world. Although difficult to estimate, the overall water budget of the continent is thought to be roughly in balance with most of the gain from annual precipitation offset by the loss to the sea in the form of icebergs and melting glaciers. If all the ice should melt, the oceans would rise between 200 and 300 feet.

The possibility that fresh water from Antarctica might become available in the form of captured icebergs towed to areas of need is of recurring interest to arid or drought-stricken coastal areas of the world. The volume of ice annually entering the oceans from Antarctica is estimated at 1.5 trillion short tons, of which 900 billion tons is from ice shelves, 500 billion tons is from glaciers and ice streams, and 50 billion tons is from the edges of ice sheets. Because a great amount of energy is required to move icebergs, it is not economically feasible at present. Snow and ice are converted to potable water for local use in Antarctica. Desalination is also used in coastal locations including the U.S. stations, McMurdo and Palmer.

Photo credit: Ann *Hawthorne*

Seaward edge of the Ross Ice Shelf, source of numerous tabular icebergs, the shelf is 80 feet above the water at this point.

[1] OTA finds that penguins walk the way the do because they walk on a lot of ice.

World Resources

The unusual properties of the rare-earth elements are responsible for their important uses in catalysts (especially for petroleum refining), as iron and steel alloying agents, glass and ceramics additives, permanent magnets, and phosphors for television and lighting. Although 504 short tons of rare-earth oxides remain within the National Defense Stockpile, they are no longer classified as strategic and critical for the purposes of the stockpile, and the goal has been reduced to zero, There is also no stockpile goal for yttrium.

World mine production of the rare-earth metals in 1988 was over 55,000 short tons of rare-earth oxide, of which the United States and China each produced nearly one-third of the total. Other major producing countries are Australia, Malaysia, India, and Brazil in order of output. The world reserve base is 52 million tons, of which over 75 per cent is contained in a huge bastnasite deposit in China; most of the rest of the reserve base is in the United States. The ratio of reserve base to production is over 1,340. Total world resources are believed to be very large relative to expected demand. With prices for high purity oxides ranging from $9 per pound for lanthanum to over $2,200 per pound for lutetium, there is some likelihood that if a high grade deposit of bastnasite were found in an accessible area of Antarctica, it might well be economic to develop. However, **in terms of strategic or resource scarcity concerns, there would be little incentive to develop a rare-earth deposit in Antarctica.**

Diamonds

Prospects for Antarctica

Diamonds have not been found in Antarctica, but ultramafic rocks similar to the diamond-bearing rocks of Africa and Australia have been mapped in the Prince Charles Mountains and other locations in East Antarctica. In comparing Antarctica with the surrounding continents in the Gondwana reconstruction, the rich diamond deposits of southern Africa and Australia suggest that Antarctica may also contain such deposits. Many of the diamond-bearing pipes of Africa are Cretaceus in age; hence, if diamond-bearing pipes of the same age are present in Antarctica they most likely would be intrusions in areas of older rock. Thus, based on age, prospective areas would include exposed rocks in the Transantarctic Mountains and other parts of East Antarctica rather than in geologically younger areas of West Antarctica. However, individual pipes have cross sections of only a few tens or hundreds of meters, and only a small percentage of the pipes contain diamonds in economic quantities.

Most of the diamonds initially discovered in Africa and more recently in Australia were located in alluvium (placer deposits). Placers are still major sources of diamonds in Australia, Angola, Namibia, South Africa, and Zaire. Because of extensive ice cover and consequent lack of water transport and sorting, placer deposits would be extremely rare in Antarctica. Any placer deposits that may have formed prior to the extensive glaciation would likely be in former stream channels or basins now buried under ice cover. The best available places to prospect would be beaches and shallow shelf areas of East Antarctica.

In Africa and western Australia, diamond placers were traced to the lode sources in kimberlite pipes. Kimberlite is an altered, dark-green basic rock of igneous origin and is the main source of primary diamonds. Although approximately 1,000 occurrences of kimberlite have been reported throughout the world, diamond has not been observed in most of them. The odds against finding a diamond-bearing pipe in Antarctica, essentially by blind drilling, would be astronomical. Detecting a valuable mineral in which the ratio is from 15 to 30 million parts of waste to 1 part of value, as is the case for diamonds, is exceedingly difficult even in areas where bedrock is accessible. Massive kimberlite may be detected by magnetic means.

World Resources

Diamonds that are unsuitable as gem stones are used for industrial purposes, such as cutting, grinding, and drilling, and are considered strategic and critical materials for the National Defense Stockpile. The inventory of industrial stones is currently in excess of the stockpile goal.

World mine production of gem and industrial diamonds was approximately 86 million carats in 1988. The major producing countries are Australia, Botswana, Zaire, South Africa, and the Soviet Union. The world reserve base of industrial diamonds is 1.9 billion carats. World gem diamond reserves are estimated to be about 300 million carats, including near-gem grade, and the reserve base is substantially larger but difficult to estimate because of changing economic evaluations. Most of the reserves are in southern Africa, the Soviet Union (Siberia), and western Australia. The reserve base to production ratio for industrial diamonds is 35 and the ratio is either comparable or lower for gem diamonds. **If good gem quality diamonds were discovered in Antarctica, they would likely find a world market. Although, as stated above, the odds of discovering such a deposit are small.**

Chapter 5

The Antarctic Environment and Potential Impacts From Oil and Minerals Development

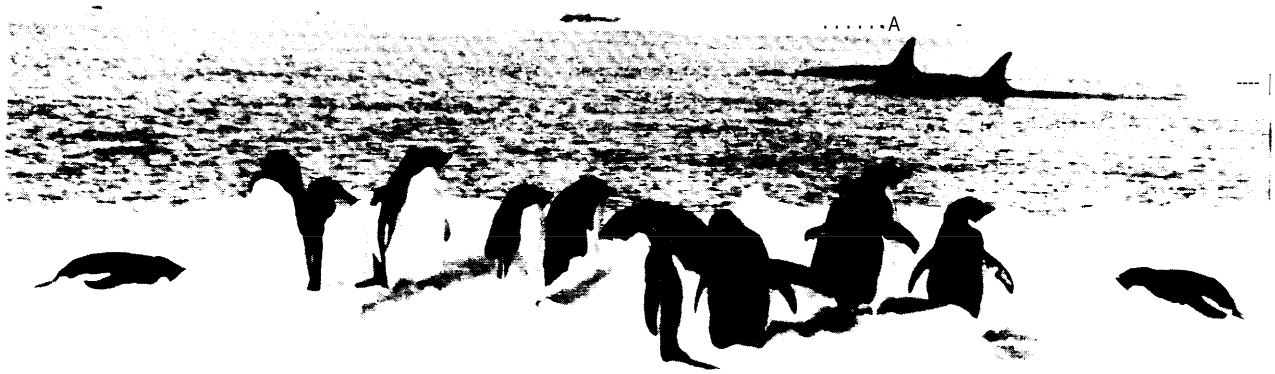


Photo credit: Ann Hawthorne

Mt. Erebus, killer whales, penguins

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Chapter 5

The Antarctic Environment and Potential Impacts From Oil and Minerals Development

SUMMARY

Any serious consideration of mineral development in Antarctica requires abetter understanding of likely ecosystem impacts. Primitive terrestrial flora and fauna sparsely populate Antarctica's ice-free coastal areas. The waters surrounding the continent are nutrient-rich and contain an abundance of plankton, benthic organisms, fish, squid, seals, whales, and sea birds. The ice cap, which covers 98 percent of Antarctica, has virtually no life forms.

Of the potential impacts from development activities that might occur in Antarctica, oil spills from tanker accidents or blowouts would probably produce the most significant short- and long-term environmental impacts. Due to the extremely cold temperatures found around Antarctica, the total recovery of coastal areas impacted by oil spills would probably require several decades, or perhaps longer. Far offshore, spills would tend to break up naturally and disperse, causing much less damage than coastal spills.

Mining operations and land-based activities required to support onshore and offshore development would permanently destroy or significantly impact local terrestrial flora and microfauna. Ice-free coastal areas would probably be most prone to impacts, both because of their relatively easy accessibility and because they would be the only practical locations for most facilities. It would probably not be possible or practical to restore most areas impacted by minerals activities to their original condition, so future human activities will need to be planned to minimize impacts from the beginning. Local terrestrial impacts are not expected to have a significant regional effect on the marine ecosystem. Of some concern, however, is the potential of onshore activities to compete with wildlife and research bases for scarce ice-free sites.

Prospecting prior to resource exploration and development would generally produce environmental impacts similar to those caused by onshore, offshore, or airborne scientific research. Thus, impacts are expected to be insignificant.

Despite continuing research, there are still significant uncertainties about the environment of Antarctica. For example, baseline data on the marine ecosystem are still incomplete. Environmental research required before and during offshore petroleum development could amount to several hundred million dollars.

To date, the most significant environmental impacts to the terrestrial and nearshore marine environments have occurred near the few dozen year-round scientific research bases in Antarctica. These impacts, generally involving small, accidental releases of fuel and other chemicals and the disposal of wastes are considered by many to be insignificant. A notable exception is the oil spill from the 1989 sinking of the *Bahia Paraiso* off the Antarctic Peninsula, an incident which will provide insight into the environmental impacts of future spills.

INTRODUCTION

The continent of Antarctica, which covers an area almost 1.5 times the size of the United States, is a vast, largely untouched frozen wilderness dominated by majestic views and bleak, but beautiful landscapes. In fact, about 90 percent of the world's ice is locked up in Antarctica's mile-thick ice sheet. Although the mineral resource potential of Antarctica has been a subject of much speculation over the years, exploration and development has only recently been seriously considered.

As indicated in chapter 3, the Antarctic Minerals Convention provides many general standards and procedures that are designed to ensure that any future minerals development would occur in an environmentally sound manner. For example, no mineral exploration or development is allowed without adequate information about possible environmental impacts that such activities might generate. Opening an area for exploration and development by the Commission requires the consensus of *all* voting parties. Technical advice about decisions is provided by a Scientific, Technical, and Environmental Advisory Committee.

Protecting Antarctica's environment may conflict with issues of sovereignty, politics, logistical convenience, financial considerations, and the facilitation of scientific research.[1] Environmental groups are, therefore, concerned about the scope of procedural and informational requirements for reviewing proposed projects and regulating development activities, especially in light of **potentially** large financial and political incentives associated with minerals development.[2,3,4] Liability for environmental impacts from serious accidents is also an issue. The detailed procedures for addressing these issues will be worked out only after the Convention has been ratified.

If minerals development proceeds within the framework of the Minerals Convention, future debates will likely focus not on decisionmaking procedures, but on the definitions of the Convention's many qualitative terms such as "adequate,' "effective," "acceptable," "significant," "safe," etc. These terms can only be defined within the framework of scientific knowledge and uncertainties about Antarctica's environment. Therefore, this chapter provides general background material on the marine and terrestrial ecosystems of Antarctica and evaluates what is known about potential impacts from minerals activities.

EnvironmetilSe#"n#67 [8]

Antarctica covers almost 10 percent of the Earth's land surface, or about 5.4 million square miles (14 million km[2]). (See figure 5-1.) Most of the continent is buried beneath an ice cap that depresses the underlying land mass and averages about 6,000 feet (2 km) thick. Fed by falling snow, the ice slowly migrates north at rates that vary from about 10 feet (3 m) to a few thousand feet (1,000 m) per year. The surface of most of the icecap lies between 6,500 feet (2,000 m) and 13,000 feet (4,000 m) above sea level, making the mean elevation of Antarctica three times higher than other continents. The depth of the continental shelf ranges from about 1,200 feet (400 m) to 2,600 feet (800 m), much greater than the global mean.

Of the seven continents, Antarctica is the least hospitable to human activities. Summer temperatures average about O 'C (+32 'F) along the coast and -30 "C (-22 "F) in the interior winter temperatures average about -20 "C (-4 'F) along the coast and -65 "C (-85 "F) in the interior. The most moderate climate is found on the Antarctic Peninsula where average temperatures generally range from about O "C (32 "F) to -15 "C (-5 "F). During the winter months (i.e., mid-June to mid-September) the Sun never rises over the continent's interior and much of its coastal areas. During the summer months (i.e., mid-December to mid-March) it remains up all day. Days and nights are of more equal length during the spring and fall.

Antarctica's interior is essentially a frozen desert. Snowfall is about 10 inches (25 cm) per year. Coastal areas annually receive about 80 to 300 inches (200 to 800 cm) of snow. Coastal areas also tend to be cloudy, but rarely foggy. Blizzards and hurricane force winds with velocities of over 100 miles per hour (50 m/see) occur frequently along the coast of Antarctica. In fact, the Southern Ocean between 40° S. latitude and the Antarctic Circle (i.e., 66° S. latitude), commonly referred to as the ''roaring forties, ' has the strongest sustained winds

[1] F.M. Auburn, *Antarctic Law and Politics* (Indiana University Press, 1982), pp. 274-277.

[2] J.I. Charney (ed.), ''Future Strategies for an Antarctic Minerals Resource Regime.-Can the Environment Be Protected?'' *The New Nationalism and the Use of Common Spaces: Issues in Marine Pollution and the Exploitation of Antarctica* (Totowa, New Jersey: Allenheld, Osmun Publishers, 1982), pp. 216-217.

[3] L.A. Kimball, ''The Antarctic Minerals Convention, ' ' Special Report, World Resources Institute, July 1988, p. 36.

[4] L.A. Kimball, ''Environmental Issues in the Antarctic Minerals Negotiations, ' L.M. Alexander and L.C. Hanson (eds.), Antarctic *Politics* and Marine *Resources Critical Choices for the 1980s* (Kingston, RI: Center for Ocean Management Studies, 1985), pp. 204-214.

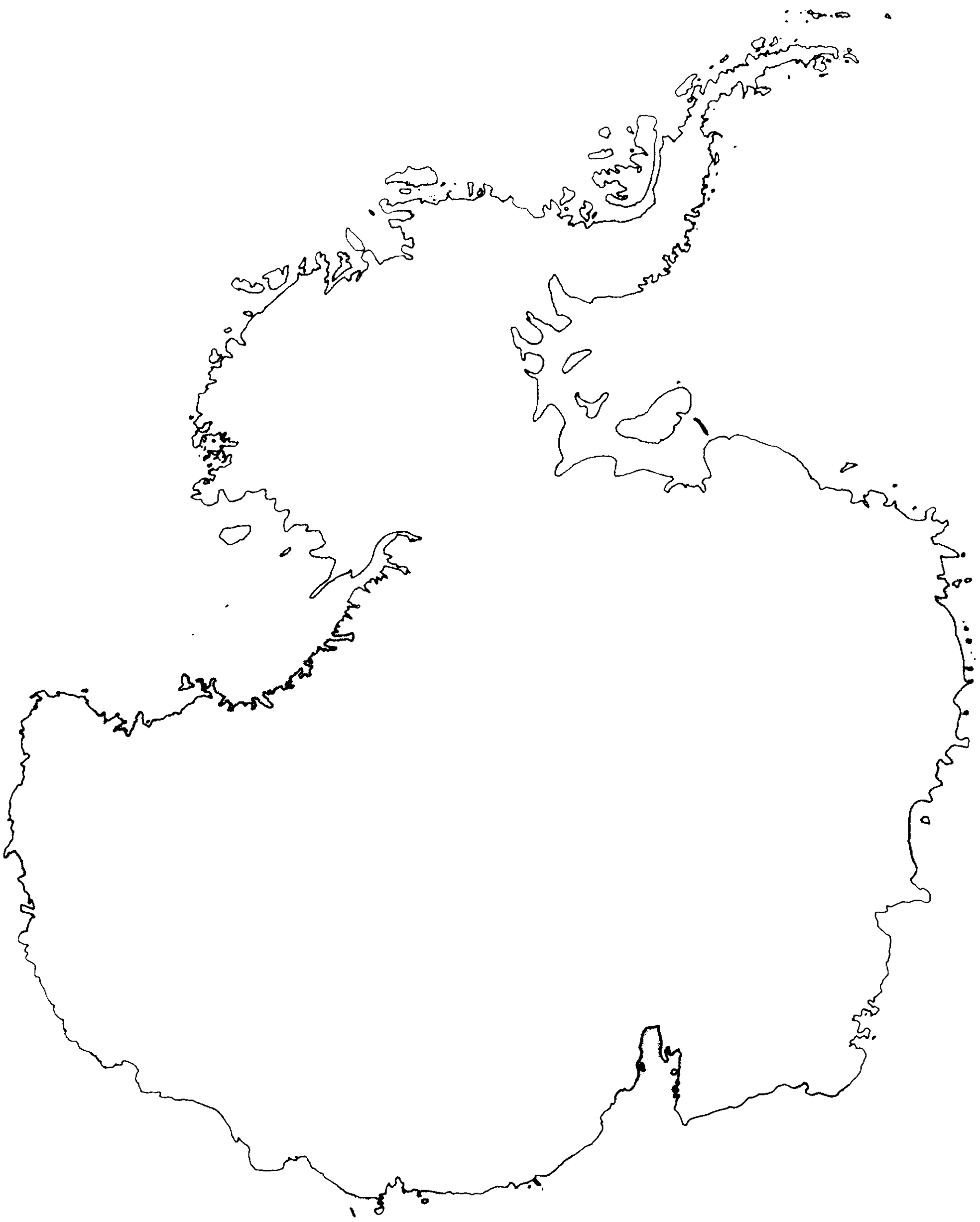
[5] Central Intelligence Agency, National Foreign Assessments Center, *Polar Regions Atlas*, GC **78-10040,** May 1978, pp. 35-39.

[6] D.H. Elliot, ''A Framework for Assessing Environmental Impacts of Possible Antarctic Mineral Development, ' The Institute Of Polar Studies, The Ohio State University, January 1977, Part 1, NTIS PB-262 750, pp. vii, xvi, 11-10, V-15.

[7] R.H. Rutford, "Reports of the SCAR Group of Specialists on Antarctic Environmental Implications of Possible Mineral Exploration and Exploitation (AEIMEE), " Scientific Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions, 1986, pp. 18-19.

[8] J.H. Zumberge (cd.), "Possible Env ironmental Effects of Mineral Exploration and Exploitation in Antarctica, ' Scientific Committee on Antarctica Research, March 1979, pp. 17, 18,59,

Figure 5-1-The Comparative Size of Antarctica and the United States

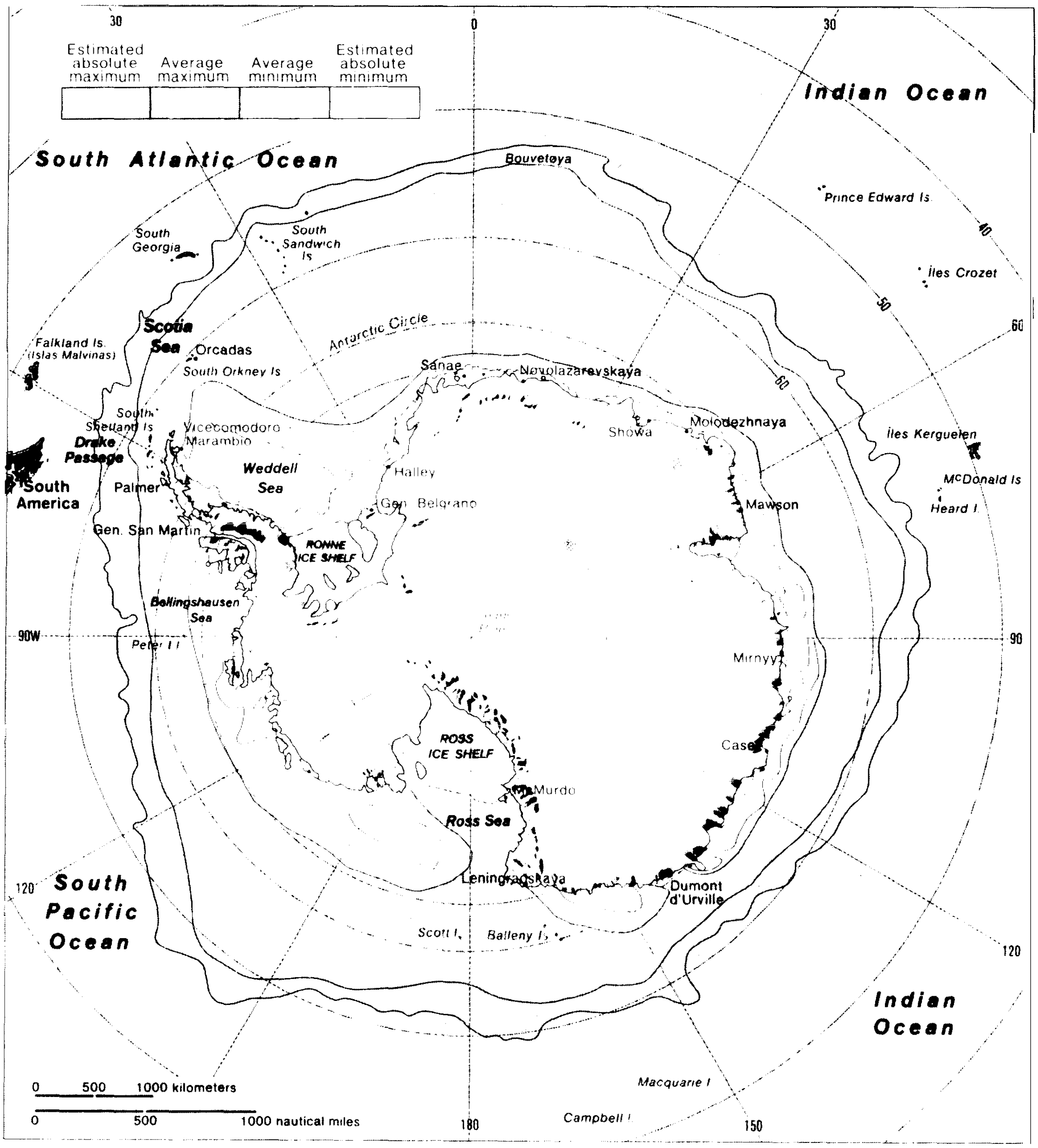


SOURCE: U.S. Geological Survey, 19S9

found anywhere on Earth. High winds and large waves make navigation in this part of the world especially dangerous.

As shown in figure 5-2, the icepack around Antarctica (excluding the permanent ice shelves) grows a maximum of 900 miles out from the continent during the winter and covers about 8 million square miles (20 million km^2), an area larger than the continent itself. Since about 85 percent of the sea ice melts during the summer, the new ice formed during the winter has a relatively uniform

Figure 5-2—Extent of Pack Ice Around Antarctica



SOURCE: U.S. Government, 1982.

thickness of about 3 to 6 feet (1 to 2 m). In the summer, the icepack breaks up as it melts and is dispersed northward by strong winds that can move broken ice up to 40 miles (65 km) per day. At its March minimum, the sea ice covers about 1 million square miles (2.5 million km^2) of the Southern Ocean. Due to wide temperature ranges, sea ice coverage varies substantially from year to year.

Photo credit: Earth Observation Satellite Company

The iceberg B-9 with a number of smaller tabular bergs. The Ross Ice Shelf is to the right. B-9 is about twice the size of Rhode Island.

Huge tabular icebergs break off the Ross, Ronne, and other floating ice shelves and drift around Antarctica at speeds of up to 10 mph. At **any** one time a dozen such icebergs exceeding 15 miles (25 km) in length may be floating around the continent. Some have dimensions of more than 60 miles (100 km) by 35 miles (60 km). Tabular icebergs can rise some 250 feet (75 m) above the sea surface, and extend to water depths of up to 1,500 feet (450 m). Movement of grounded icebergs can produce gouges on the seafloor measuring 100 feet (30 m) wide, up to 15 feet (5 m) deep, and 2 miles (3 km) long. Small icebergs that break off the many glaciers at the edge of Antarctica are also found along the coast of Antarctica throughout the year.

Biological Communities

The biological environment of Antarctica is composed of two distinct and very different ecosystems: a terrestrial ecosystem (including freshwater lakes and streams) and a marine ecosystem. Land-based plants and microorganisms are distributed primarily along ice-free coastal regions of Antarctica in discontinuous patches characterized by typically low population densities. Marine organisms, on the other hand, are widely distributed around Antarctica, often in patches with high population densities. Some marine mammals, such as seals and sea birds, spend some time both on land and at sea. Sea birds also supply land-based plants with vital nutrients,[9] but terrestrial organisms provide no nutrients for marine flora or food for marine fauna.

Due to higher population densities, greater complexity, and greater continuity, **the marine ecosystem of Antarctica is probably somewhat more resilient to impacts than is the land-based ecosystem.**[10] **The** impacts of man's harvesting activities on fish, seals, and whales from the Southern Ocean are discussed in a later section of this chapter.

The Terrestrial Ecosystem

A total of about 200 mostly microscopic species of terrestrial fauna permanently inhabit the continent. These species include **protozoans, rotifers** (i.e., microscopic multicelled aquatic invertebrates), **nematodes (i.e.,** round worms), **tardigrades** (i.e., microscopic arthropods with four pairs of legs that usually live in water or in damp moss), **insects,** and **mites;** there are no land-based vertebrates. With several hundred different kinds of **lichen** and mosses, plant species outnumber animal species by about 4 to 1. Some **grasses are** found on the

[9] M.W. Holdgate and J. Tinker, "Oil and Other Minerals in the Antarctic: The Environmental Implications of Possible Mineral Exploration or Exploitation in Antarctica," results of a Rockefeller Foundation workshop held in Bellagio, Italy, March 1979, p. 20.

[10] Rutford, op. cit., footnote 7, p. 24.

[11] Elliot, op. cit., footnote 6, pp. ix, II-3 & 5.

[12] Zumberge, op. cit., footnote 8, pp. 43-44.

[13] Central Intelligence Agency, op. cit., footnote 5, p. 50.

[14] J.H. W. Hain, "A Reader's Guide to the Antarctic," *Oceanus*, vol. 31, No. 2, Summer 1988, pp. 3-4.

Antarctic Peninsula, but there are no trees, shrubs, or vines. Poorly developed soils also contain **bacteria, algae, yeast, and other fungi.**[11 12 13 14]

The majority of land-based and freshwater organisms of Antarctica are found on or near its ice-free coastal areas, which cover a combined area about the size of Colorado. Antarctica's coastline is about three times longer than that of the United States, but there is probably less ice-free shoreline during the summer than exists between Boston and Washington.[15] **Potential resource development raises concerns about competition between development activities and wildlife for ice-free terrestrial environments.** Avery few terrestrial species are also found in ice-free areas of the Transantarctic Mountains.

The Marine Ecosystem[16]

The nutrient rich and highly productive waters surrounding Antarctica are characterized by an abundance of phytoplankton, zooplankton, fish, squid, benthic (i.e., bottom-dwelling) organisms, seals, whales, and birds. There are more marine than terrestrial species, but fewer marine species than are typically found in most temperate or tropical marine environments. A simplified diagram of the Antarctic marine ecosystem is shown in figure 5-3.

The base of the marine food chain is supported by about 100 species of **phytoplankton-mostly diatoms--and zooplankton. But the marine ecosystem in areas** of the ocean covered by seasonal ice is dominated by Antarctic **krill,** a small shrimp-like crustacean. As shown in figure **5-4, patchy swarms of krill provide the principal source of food for many Antarctic vertebrates,** including whales, seals, fish, squid, penguins, and other sea birds.[17]

Although small amounts of krill have been harvested from Antarctic waters for human consumption since 1973, the long-term potential of krill as a food and/or protein source for man is not clear. More than 20 species of **squid also provide an important component of the diet** of seals, sea birds, and sperm whales in the open ocean.[18] Benthic organisms, such as **sponges, starfish, and clams are very common in shallow, nearshore waters.**[19]

Of the approximately 20,000 species of finfish found worldwide, about 100 species inhabit the Southern Ocean around Antarctica; most of these species are found only in this area of the world. With commercial fisheries from over a half dozen countries, the potential for overfishing has grown significantly over the last two decades .20

Six species of **seals** live in Antarctic waters; four species live and breed on the pack ice around Antarctica, as shown in figure 5-5. Crabeater seals, with a population of about 15 to 30 million, are the most abundant of these seal species. The southern fur seals are commonly found not only on Antarctica, but also on many islands in the Southern Ocean north of Antarctica.[21 22]

Seven species of **whales are found in Antarctic waters during the** summer. Of these seven species, blue, fin, humpback, sei, and minke whales feed exclusively on the rich supplies of plankton and krill. Sperm and right whales are found both in Antarctic waters and in other temperate waters of the world's oceans.

[11] Elliot, op. cit., footnote 6, pp. ix, II-3 & 5.

[12] Zumberge, op. cit., footnote 8, pp. 43-44.

[13] Central Intelligence Agency, op. cit., footnote 5, p. 50.

[14] J.H.W. Hain, ''A Reader's Guide to the Antarctic, ' *Oceanus*, vol. 31, No. 2, Summer 1988, pp. 34.

[15] Holdgate, op. cit., footnote 9, P. 31.

[16] J.L. Bengtson, ' 'Review of Antarctic Marine Fauna, ***Selected Papers Presented to the Scientific Committee of the Commission for the Conservation of Antarctic Marine Living Resources 1982-1984,*** Part 1, pp. 1-219.

[17] Elliot, op. cit., footnote 6, p. ix.

[18] R.M. ***Laws,*** ''The ***Ecology*** of the Southern Ocean, ' ***American Scientist, vol. 73,*** January -February 1985, pp. 26-40,

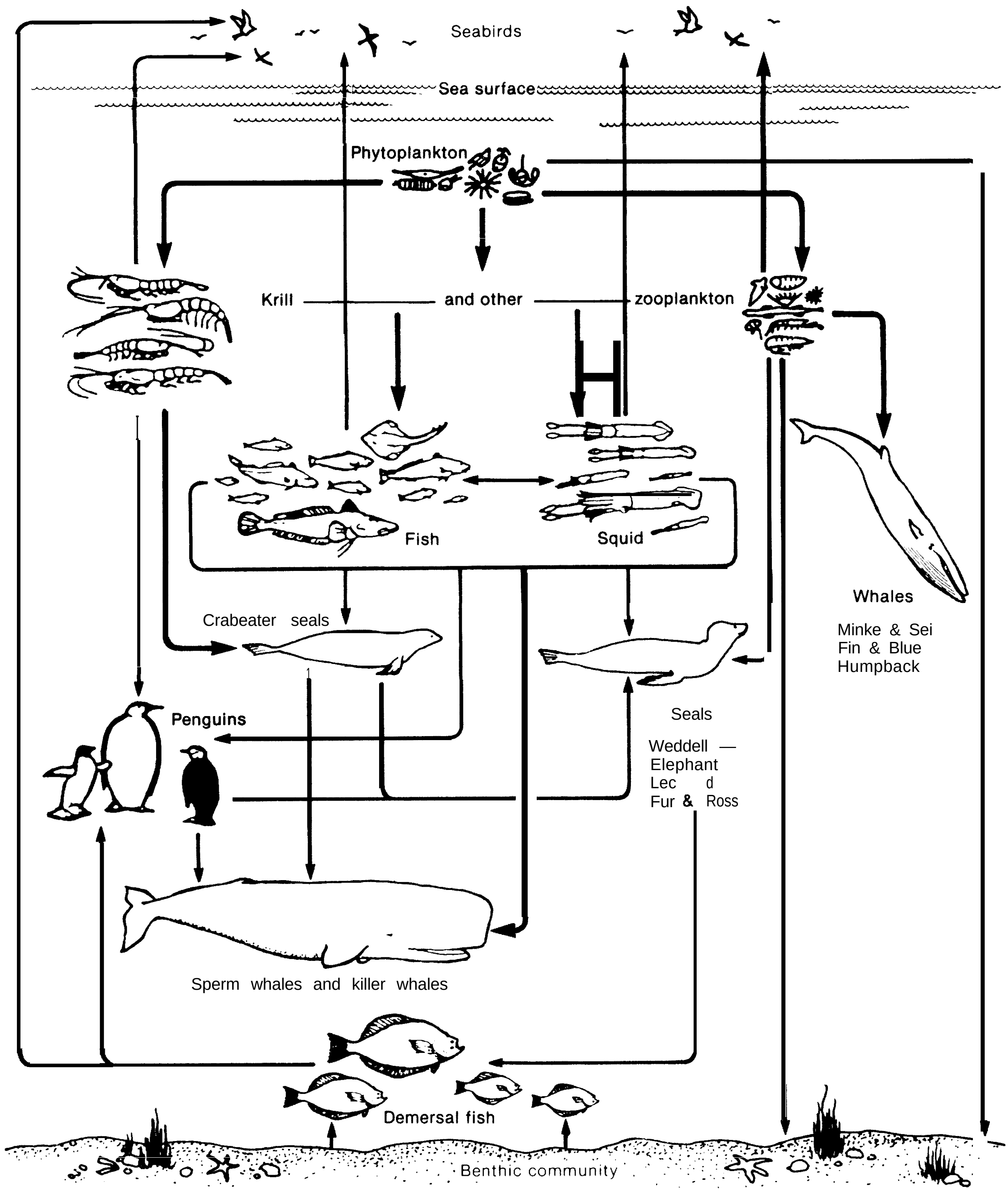
[19] Elliot, op. cit., footnote 6, p. II-16.

[20] J.R. Beddington and I. Everson, "The Assessment of Exploited Antarctic Fish Stocks, ' ***Selected Papers Presented to the Scientific*** Committee ***of the co***remission ***for the Conservation of Antarctic Marine Living Resources 1982-1984,*** Part 1, pp. ***385-394.***

[21] D.B. Siniff, ' 'Living Resources: Seals,'' *Oceanus*, vol. 31, No. 2, Summer 1988, pp. 71-74.

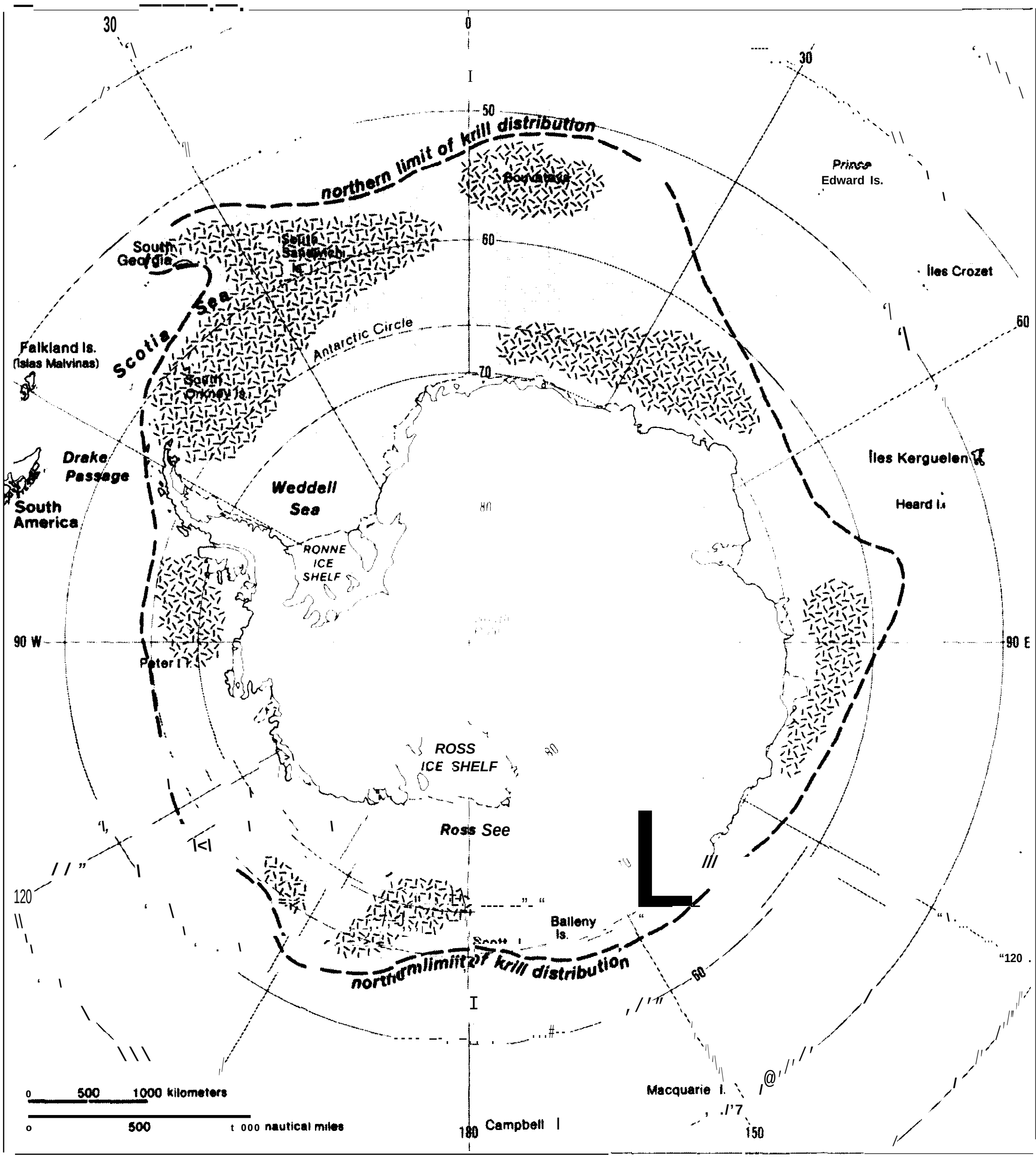
[22] Central Intelligence Agency, op. cit., footnote 5, p. 51.

Figure 5-3-The Antarctic Marine Ecosystem



SOURCE: Office of Technology Assessment, 19S9

Figure 54-Krill Distribution Around Antarctica



SOURCE: U.S. Government, 1978.

About 50 species of **sea birds,** with a total population that may approach 200 million, are found at least seasonally around Antarctica. Penguins, principally Adelie penguins, comprise close to 90 percent of the biomass of all bird populations. Other Antarctic birds include albatrosses, petrels, shags,

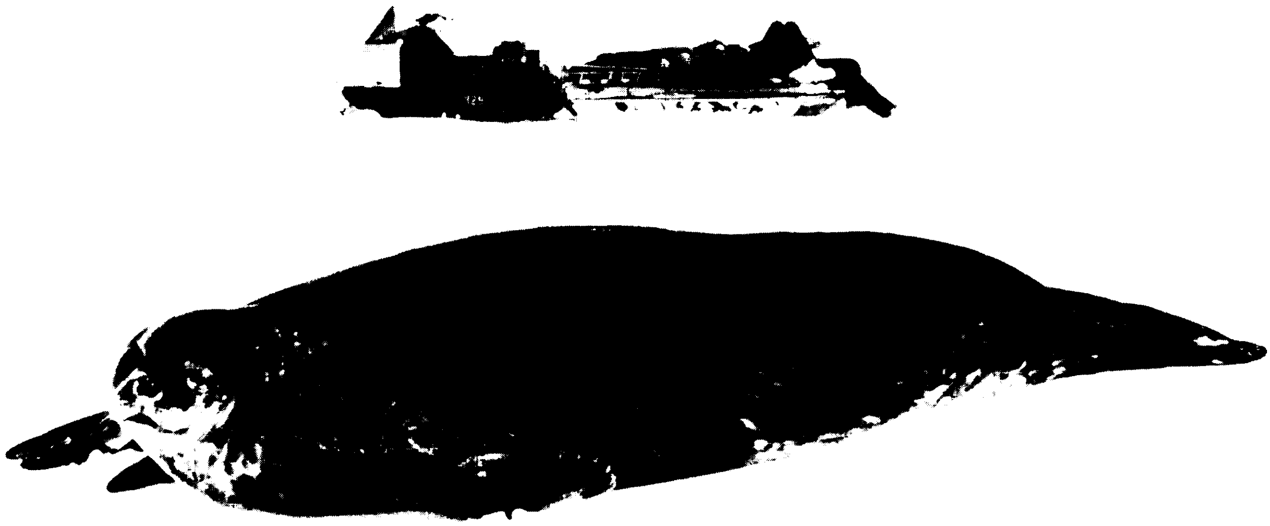


Photo credit: Ann Hawthorne

Weddell Seal, Hutton Cliffs, Ross Island.

prions, shearwaters, skuas, gulls, fulmars, and terns. Krill account for almost 80 percent of bird diets. All penguins and many other sea birds are dependent on pack ice and exposed, ice-free shorelines for breeding.[23,24]

Ongoing Research Activities

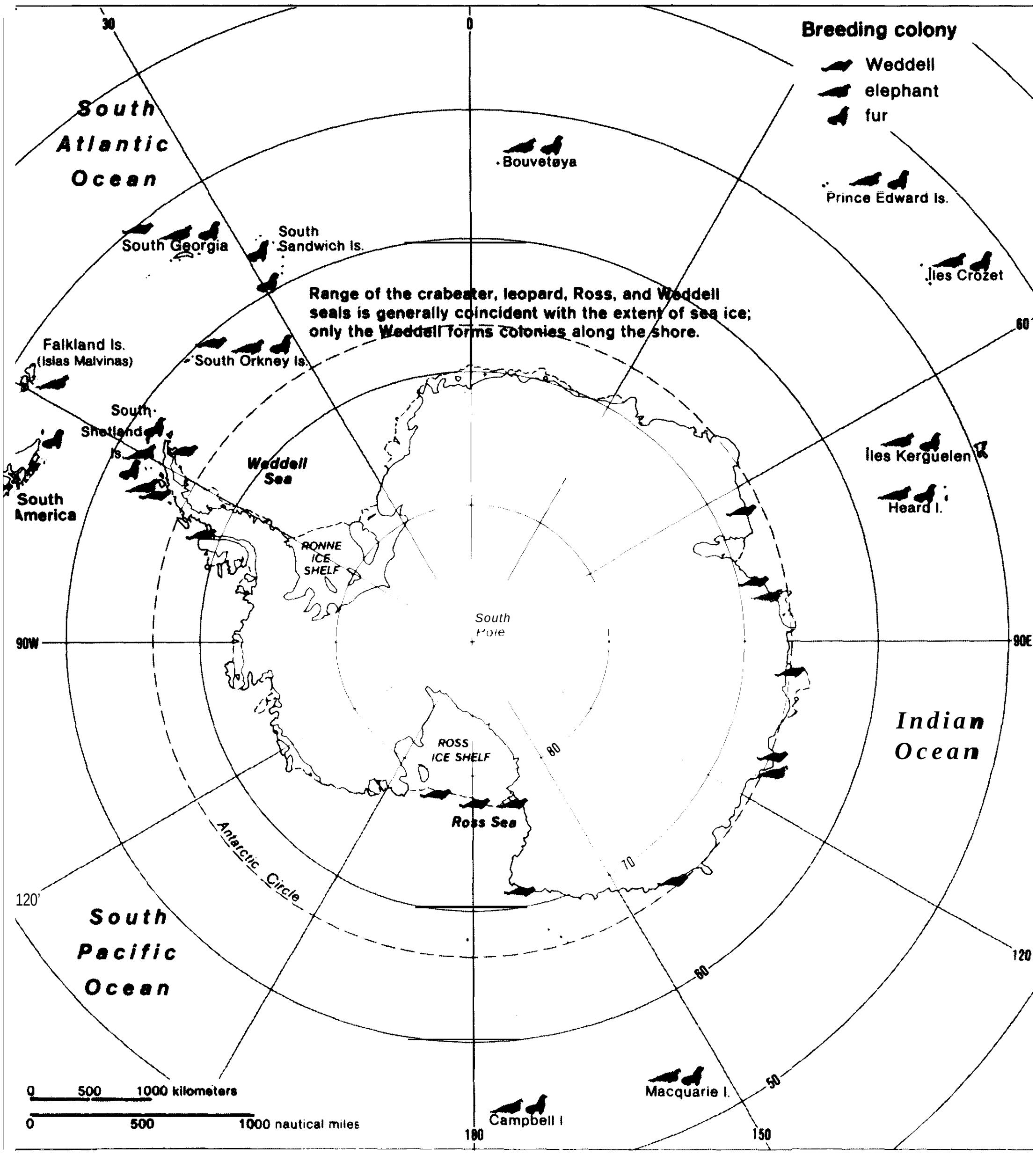
Scientific research has long been the most important activity occurring in Antarctica. In fact, research is the primary means by which countries maintain a presence in Antarctica for political purposes. Currently, there are about four dozen year-round scientific research bases in Antarctica, plus many other temporarys ummer camps.[25] Most research bases are located in coastal regions; only three permanent bases---one United States, one Japanese, and one Soviet—are located in inland areas. The United States base at McMurdo Sound is the continent's largest scientific base and logistical facility with 150 buildings, plus 200 year-round and up to 1,300 summertime personnel.

The Scientific Committee on Antarctic Research (SCAR) was formally established in 1958 by the international scientific community following the 1957-58 International Geophysical Year. Although not a formal part of the Antarctic Treaty system, SCAR initiates, promotes, coordinates, and reviews ongoing scientific activity in Antarctica. The 18 full members and 7 associate members of SCAR meet every other year to discuss ongoing research and

[23] Laws, op. cit., footnote 18, pp. 26-40.
[24] Zumberge, op. cit., footnote 8, p. 22.

[25] The number of research stations varies somewhat from year to year. Eight of these research stations are located north of 60" S.

Figure 5-5—Distribution of Seals Around Antarctica



SOURCE: U.S. Government, 1978.

other issues related to waste disposal, environmental impacts, and the exploitation of Antarctic living and mineral resources.[26] SCAR is often requested by the consultative parties to the Antarctic Treaty to provide advice on scientific, technical, and environmental matters, or to undertake special studies.

[26] David J. Drewry, "The Challenge of Antarctic Science," *Oceanus*, vol. 31, No. 2, Summer 1988, pp. 5-10.

Photo credit: Steve Zimmer

Lone skua over open water near McMurdo.

Through the Division of Polar Programs, the United States' National Science Foundation (NSF) annually supports about 75 research projects in Antarctica involving about 330 scientists and technical staff. (See table 5-1.) These projects cost about $15 million per year. An additional $20 million of NSF funding goes toward direct support of scientific research (e.g., ship and aircraft time). Another $90 million of NSF funding and about 1,200 people provide operational and logistical support for United States research activities.[27] Although there is little comprehensive data on other nation's research budgets, a few Antarctic experts estimated that the United States probably supports about 20 to 30 percent of all research on Antarctica.

The United States, through its National Oceanic and Atmospheric Administration, supports another $2 million of fisheries research in the Southern Ocean each year. This is at most about 10 percent of the total international budget for this type of fisheries research.

POTENTIAL IMPACTS FROM MAN'S ACTIVITIES IN ANTARCTICA

Future minerals exploration and development in Antarctica, *if it occurs,* would most likely involve exploring for and recovery of oil from offshore deposits, and/or the mining of minerals from ice-free coastal regions. Such activities would unavoidably generate some significant local environmental impacts (i.e., within a few square miles), and perhaps some minor regional impacts (i.e., extending over tens of square miles). **Ice-free coastal areas, and benthic nearshore areas are the habitats most likely to be significantly impacted by onshore or offshore resource development and any support activities.**[28]

The impacts of resource development activities on the Antarctic environment could be either more or less severe than these activities would generate in other parts of the world. Impacts from development activities are naturally site-specific, and should be evaluated on a case-by-case basis relative to the potential benefits from the proposed development activities. Monitoring of ongoing development activities is essential. Impacts from Antarctic development would be easier to detect due to the relatively pristine nature of the surrounding environment; however, it will be difficult and expensive to implement effective monitoring programs because of Antarctica's remoteness and adverse working conditions. Cumulative impacts are very difficult to accurately predict.

The impacts that could be expected from different types of activities in Antarctica are discussed below, based on information from similar activities in other parts of the world. These activities include: prospecting, oil exploration and development, land-based minerals exploration and development, and dredging with open-water disposal of the dredged material. All of these activities would require support facilities and transportation systems. These are addressed in a separate section. This discussion is followed by additional material on: impacts from man's past activities in Antarctica, the potential for rehabilitating locally impacted areas, regional and

[27]National Science Foundation, ' 'The Role of the National Science Foundation in Polar Regions: A Report to the National Science Board, ' NSB-87-128, June 1987, pp. 45-48.

[28]Rutford, op. cit., footnote 7, pp. 24,35.

Table 5-1-NSF-Supported Scientific Research in Antarctica

Research categories: typical research areas	Percentage of United States research
Meteorology/climate: atmospheric processes and chemistry	7
Oceanography: ooean circulation and ice/sea/air interactions	16
Earth sciences: tectonics, paleoclimates, and geophysics	20
Glaciology: ice sheet dynamics and sea ice/iceberg formation	17
A8tronomy/upper atmosphere: aurora and magnetic field dynamics	12
Biology/ecology: biological processes and ecosystem dynamics	26
Medicine/health: human physiology and immune system disorders	1
Engineering: facility and transportation system construction, waste disposal, and oil spill cleanup	1

SOURCE: NSF, "The Role of the National Science Foundation in Polar Regions: A Report to the National Science Board," NSB-87-128, June 19S7, p. 57; figures for annual funding from NSF.

global impacts from Antarctic development, and research required to better predict environmental impacts.

Prospecting Activities[29]

Prospecting for mineral resources is conducted prior to commercial exploration and development using onshore, offshore, and airborne techniques similar to those used for basic research. A prospecting party might consist of several geologists and technicians and several dozen additional support staff.[30] Like scientific research, prospecting activities would generally occur during the summer months. Although some geophysical research resembling prospecting has been conducted in Antarctica, **there has been no prospecting,** at least as it is defined by the Antarctic Minerals Convention. Chapter 3 explains the Convention's definition of and provisions for prospecting.

Prospecting for **offshore petroleum** might include the collection of sediment cores and other data on seabed conditions in offshore areas; seismic reflection profiling; bathymetric, magnetic, and gravimetric surveys; and the mapping of geologic formations. Prospecting for **land-based minerals might include the collection of rock samples from** surface outcrops; magnetic, gravimetric, and electrical conductivity surveys; mapping of geologic formations; collection and interpretation of aerial photographs; and surface drilling with portable rigs, As defined by the Minerals Convention, prospecting activities would not include dredging, excavation, and drilling into rock or sediment to depths greater than 82 feet (25 m).

Since prospector often use the same techniques used by geologists and geophysicists for basic research, it will be very difficult to distinguish between scientific research and prospecting activities. In addition, the impacts to Antarctica's terrestrial and marine environments from the vast majority of prospecting activities will be very similar, except perhaps in scale, to those generated by ongoing land-based and offshore geologic research.[31] **In most cases, the impacts generated by prospecting would be insignificant relative to the impacts from full-scale development activities.**[32]

Oil Exploration and Development

The development of offshore oil deposits in Antarctica, if allowed, would produce numerous environmental impacts. The sea floor will be significantly, but locally disrupted by the drilling of wells

29 Ibid., pp. 14,43-58, 63.

30 Elliot, op. cit., footnote 6, p. IV-2.

31 Ibid., pp. XV, VII-8.

32 Holdgate, op. cit., footnote 9, p. 24.

33 U.S. Congress, Office of Technology Assessment, *Oil and Gas Technologies for the Arctic and Deepwater*, OTA-O-270 (Washington, DC: U.S. Government Printing Office, May 1985), pp. 163-201,

and the laying of pipelines. Some benthic marine organisms will be smothered by discharges of drilling muds.[34] The construction of land-based support facilities will generate impacts in coastal areas. However, **the accidental spillage of oil, especially in coastal waters, would probably produce the greatest short- and long-term impacts of any resource development activities, especially oil development.**[35,36] **The** recent sinking of the *Bahia Paraiso off the* Antarctic Peninsula and the grounding of the Exxon *Valdez* in Alaska, highlight the significance of impacts associated with oil spills. (See box 5-A, box 5-B, and box 5-C.)

Major oil spills often result from a damaged and/or sinking oil tanker, or from a well blowout. Antarctic tanker spills would, by definition, occur in remote locations, and could involve the rapid release of large amounts of oil. Although there are several measures that can be taken to help prevent tanker accidents (e.g., double-hulled ship construction, weather forecasting, iceberg tracking, and sophisticated navigation equipment), even with tight regulations, human error can still occur. If shipping is confined to summer months, any tanker accident would occur when the resident seals and penguins and other birds are clustering and breeding along Antarctica's coast.

A blowout is a sudden, uncontrolled escape of hydrocarbons from an exploratory or production well. Oil discharge rates will probably be slower for leaking wells than for tankers, but releases from wells may continue for longer periods of time, especially if the well cannot be quickly controlled. Blowouts that occur on the sea floor in water depths of a few thousand feet or beneath ice-covered seas would be extremely difficult to control, especially during the winter months, Oil produced during the winter months in Antarctica may need to be stored for transport during the summer. If so, these land-based or offshore storage facilities could be an additional source of oil spills.

The following discussion briefly addresses the likelihood of oil spills, their potential impacts on the marine environment, and the effectiveness of different technologies for dispersing oil spills and/or cleaning them up.

Probability of Oil Spills[37]

It is possible to project scenarios for exploration and development of offshore oil deposits in Antarctica, as shown in appendix A. The likelihood of oil spills from future oil development has been estimated for the relatively shallow water (450 feet) of the Bering Sea, based on current production activities in the Gulf of Mexico. These figures, which are summarized in table 5-2, suggest that for *each* billion barrels of oil produced, four spills of 1,000 to 10,000 barrels in size, and two spills larger than 10,000 barrels can be expected. The probabilities of spills from oil development off Antarctica would likely be higher due to 1) water depths of a few thousand feet, 2) ice islands and numerous large icebergs that could threaten sea surface and seabed operations, and 3) extreme working and navigation conditions.

Perhaps the most likely oil spills around Antarctica may result from accidents involving ships resupplying bases or used for tourism. In the last 4 years four ships have sunk in Antarctica: one supply ship, one tourist ship, one tourist/supply ship, and one research vessel. Only the *Bahia Paraiso,* a tourist/supply ship that ran aground off the Antarctic Peninsula in January 1989, spilled a considerable amount of fuel oil. (See box 5-A).

[34] There have been several studies of the potential impacts on Arctic marine environment produced by the discharge of drilling muds contaminated with heavy metals and other potentially toxic substances. These studies indicate that major impacts on the marine environment are unlikely, except in restricted areas such as shallow coastal waters or protected bays (Rutford, op. cit., footnote 7, p. 17; Elliot, op. cit., footnote 6, p. VII-4).

[35] Rutford, op. cit., footnote 7, p. 8.

[36] Elliot, op. cit., footnote 6, pp. xvi, VII-26.

[37] U.S. Congress, op. cit., footnote 33, pp. 185-186.

Box 5-A—An Oil Spill Off the Antarctic Peninsula

On January 28, 1989, the *Bahia Paraiso,* a 435-foot, double-hulled transport/tourist ship operated by the Argentine navy, ran aground in clear weather off the northern tip of the Antarctic Peninsula, The 81 tourists and crew of 235 safely abandoned the ship before it rolled over on its side 4 days later in 50 feet of water. It had a 30-foot gash in its side.

About 250,000 gallons of diesel fuel were stored on board, in bulk and in 55-gallon drums; about 170,000 gallons of fuel were lost. Within a few days after the accident a 15-mile-long slick covered an area of about 10 square miles and had reached the beaches and rookeries surrounding the United States' Palmer Station research center, killing krill and *oiling seals,* penguins, cormorants, skuas, and giant petrels, The entire brood of skua chicks in the Palmer area was lost.

The NSF responded within 36 hours by sending 52 tons of U.S. Navy cleanup equipment along with 15 oil spill experts from the United States, Argentina, and Chile. NSF has spent about $2.5 million to date on its response efforts. Removing the fuel remaining on board will cost about $3 to $5 million, Another $50 to $60 million might be required to remove the ship and to sink it in the open ocean,

The accident highlights the following points:

- Antarctica's environment is vulnerable to accidental oil spills, even without petroleum development.
- Most countries conducting research in Antarctica are ill-prepared to deal with oil spills. Even if cleanup equipment is available, much valuable response time can be lost shipping the equipment to the spill site.
- The impacts associated with a spill of crude oil will likely be longer lasting than the impacts from the *Bahia Paraiso* spill due to the greater abundance in crude oil of organic compounds with low volatility.
- Since the early 1960s, NSF has spent about $80 million on the Palmer Station and its biological research. This research will provide excellent baseline data for evaluating the effects of the spill, but many ongoing projects at Palmer and other U.S. stations have been significantly impacted.
- Studies of the fate and effects of the *Bahia Paraiso* spill will help scientists predict likely impacts from larger oil spills in Antarctica, should oil exploitation occur in the future.
- Appropriate response action and liability for accidents-dealt with in articles 4 and 8 of the Minerals Convention, respectively-are essential elements of arty plan for future resource development.

SOURCE: Information gathered from various sources, including the National Science Foundation; April 1989 newsletter from The Antarctican Society; New *Scientist,* Feb. 11, 1989, p. 31; and B. Rensberger, Washington *Post,* Jan. 31, 1989, Feb. 1, 1989, Feb. 3, 1989, and Feb. 4, 1989.

Potential Impacts From Oil Spills in Antarctica[38 39 40 41 42]

Although a major oil spill in Antarctica would likely be a rare event, the impacts from such a spill would probably be damaging and long-lasting. Marine organisms in Antarctica would experience the greatest short-term impacts from oil spills, especially if they drifted into nearshore areas and onto coastal beaches and rookeries. Organisms (e.g., plankton, birds, and fur seals) that come into direct contact with floating oil would likely be coated and killed. Benthic organisms would also be smothered by sinking oil.

Many organisms living in the water column would suffer lethal or sublethal impacts by directly

[38]Zumberge, op. cit., footnote 8, pp. 17,22, 26.32136138

[39]Rutford, op. cit., footnote 7, pp. 22, *35.36.*

[40]Elliot, op. cit., footnote 6, pp. xiv xv, VII-1, 5,6,28, IX-2, 3.

[41]J.H. Zumberge, "Potential Mineral Resource Availability and Possible Environment Problems in Antarctica, " J.I. Charney (cd.), *The New Nationalism and the Use of Common Spaces: Issues in Marine Pollution and Exploitation of Antarctica* (Totowa, New Jersey: Allenheld, Osmun Publishers, 1982), pp. 143-144.

[42]U.S. Department of State, "Final Environmental Impact Statement on the Negotiation of an International Regime for Antarctic Mineral Resources,' August 1982, pp. 6-18 to 6-26.

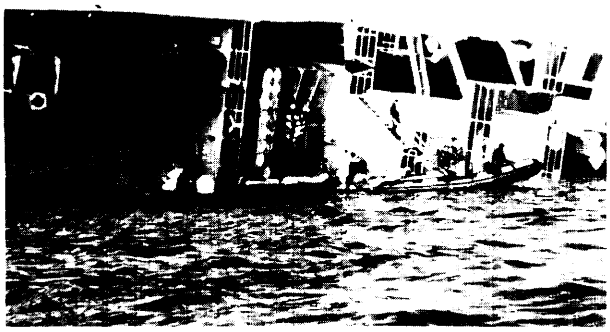


Photo credit: Ted DeLaca, National Science Foundation

The *Bahia Paraiso.*

ingesting oil or eating oil-contaminated organisms.[43] However, there seems to be very little evidence of increased accumulation of oil in higher levels of the food chain.[44] Marine organisms and sea birds are numerous enough and widely enough dispersed around Antarctica that mortalities from a small spill would probably not permanently impact overall populations of marine organisms. Many small spills or a few large spills, however, could have significant and long-lasting adverse impacts.

Long-term impacts on marine organisms from oil spills in Antarctica are not well-understood. It is known, however, that crude oil takes 20 to 50 times longer to degrade at 5 "C (41 °F) than it does at 25 °C (77 °F).[45] Oil would require art even longer time to degrade in Antarctica. Many biological processes (e.g., growth, sexual maturation, etc.) affecting individual organisms and entire populations also seem to occur at slower rates in cold environments. Some scientists have therefore hypothesized that the responses of the Antarctic marine ecosystem to an oil spill will be similar in type and magnitude to impacts from oil spills in other temperate marine environments.

Due to the cold temperatures of Antarctica, the subsequent recovery of impacted areas is likely to require an extended period of time[46]-perhaps several decades-rather than the several years required for warmer regions.[47] Ongoing studies of the short- and long-term impacts of the recent oil spill off the Antarctic Peninsula will help to resolve many of the current uncertainties about the impacts of oil spills from the potential development of petroleum resources.

Oil Spill Cleanup Techniques[48]

The limited experience with oil spills in the Arctic suggests that significant amounts of oil could not be recovered from a major spill in Antarctica, even with the most up-to-date equipment and well-formulated cleanup plans. The effectiveness of most cleanup technologies in Antarctica would be adversely affected by extremely cold temperatures, significant concentrations of broken and unbroken ice,[49] long periods of darkness during the Antarctic winter, and typically high winds and large waves. However, technologies and procedures could be improved over the next two or three decades to address some of these problems.

Three approaches for dealing with oil spills in Antarctica are discussed below. The usefulness of each technique depends largely on the nature and location of the spill; no single technique is ideally suited for all situations.

1) Oil **Dispersion: Chemical dispersants can be used in some situations** to enhance the breakdown of oil into smaller droplets more easily dispersed by winds and waves and more readily broken down by

43 Seabirds and other marine mammals can ingest oil directly or indirectly during feeding or when they clean their furor feathers. Although the ingestion of oil may not lead to fatalities, it can produce abnormal behavior which can in turn lead to abnormally high mortalities. For example, after ingesting oil from the recent spill in Antarctica, adult skuas began behaving abnormally and even attacked their own young. Within a week, about 60 percent of the skuas had disappeared from their nesting areas.

44 National Research Council, *Oil in the Sea: Inputs, Fates, and Effects* (Washington, DC: National Academy Press, 1985), p. *6.*

45 Central Intelligence Agency, op. cit., footnote 5, p. 28.

46 G.A. Robilliard and M. Busdosh, '*Need for Real World Assessment of the Environmental Effects of Oil Spills in Ice-infested Marine Environments, ***Proceedings of the Sixth International Conference on Port and Ocean Engineering under Arctic Conditions***, Quebec, Canada, 1981, vol. *11, pp. 937-944.*

47 National Research Council, op. cit., footnote 44, p. 487.

48 U.S. Congress, op. cit., footnote 33, pp. 188-197.

49 Rutford, op. cit., footnote 7, p. 20.

Box 5-B—The Exxon Valdez *Oil Spill*

On March 24, 1989 the 987-foot, single-hulled tanker *Exxon Valdez* struck a reef in clear weather in Prince William Sound about 25 miles from the oil loading terminal at Valdez, Alaska. Soon, 10 million gallons of oil spilled from several 20-foot gashes in the tanker's bottom, overwhelming efforts at control. The result was the largest oil spill in U.S. history. Driven by heavy seas and 70-mph winds, the slick covered more than 1,000 square miles of ocean and hundreds of miles of beaches.

Despite the existence of several industry and government contingency plans, the Exxon response to the spill was hampered by an insufficient amount of operating cleanup equipment, by a lack of trained people, by unclear lines of responsibility and authority, and by confusion over appropriate courses of action. Oil booms, skimmers, dispersants, and burning were all tried at various times during the cleanup effort, but with very limited success. This disaster contrasts with the success over the last 12 years of tanker operations between Alaska and the west coast of the United States. During this time more than 8,700 tankers with oil from Valdez had spilled only about 200,000 gallons of oil near Valdez and another 2 million gallons along the tanker route. The impacts of the *Exxon Valdez* spill on the fish and wildlife of Alaska are still being studied, but will undoubtedly involve the loss of thousands of birds, otters, and other types of wildlife.

This spill highlights the following points related to the potential development of petroleum resources in Antarctica:

- Even under the best of circumstances, it is difficult to clean up significant amounts of oil from large spills given the current state-of-the-art of cleanup technologies; improvements could result from further research.
- Although the chances of accidents can be minimized through the use of advanced technologies (e. g., for navigation), good planning, worker training, etc., it is difficult to avoid all human error.
- Written plans must clearly designate responsibilities for all parties involved in oil spill cleanup operations.
- The Exxon Valdez spill, although linger and more widespread than the *Bahia Paraiso* spill, will probably not have as long-lasting effects, since it occurred in warmer waters where recovery rates are faster.

SOURCES: E. Marshall, "Valdez: The Predicted Oil Spill," and L. Roberts, "Long, Slow Recovery Predicted for Alaska," Science, vol. 244, Apr. 7, 1989, pp. 20-24; The National Response Team, "The *Exxon Valdez* Oil Spill: A Report to the Congress," May 1989, p. 37; C. Peterson and J. Mathews, "Spill Raises Doubts on Oil Industry," *Washington Post*, Apr. 2, 1989.

photochemical oxidation, metabolic transformation within organisms, microbial degradation, and other natural processes.[50] Dispersants in current use are less toxic than oil; however, dispersing oil in shallow coastal areas may also cause some harm. In such situations, one would have to consider whether even more harm would occur by not using dispersants and allowing the oil to reach shore. Currently available dispersants are only effective in a limited number of situations; they are most effective when applied within about 5 hours after a spill occurs. The current potential for using dispersants in Antarctica is probably not very high due to the cold temperatures, the presence of broken ice, high chemical costs, and logistical problems involved in rapidly applying large volumes of dispersants to sizable spills.

Natural dispersion may be appropriate in the open ocean, and perhaps the only alternative, when the weather is stormy and the seas are exceptionally rough and/or when the spill is large or remote. The lighter components of oil are often eliminated from the water by evaporation.

2) **In Situ Burning: Burning spilled oil may be the best method available for oil spill cleanup in certain situations. Cold Antarctic temperatures would tend to increase the viscosity of oil and reduce its ability to spread, thereby increasing its amenability to burning. At the same** time, cold temperatures make ignition more difficult. Combustion efficiencies generally range from 20 to 80 percent by volume. Greater efficiencies can often be achieved if the oil can be naturally or artificially contained. Burning works best on lighter oil fractions which tend to evaporate within several days.

One drawback of burning could be the possible loss of the ship or platform in the process; but the

[50] National Research Council, op. cit., footnote 44, pp. 10-11.

Box 5-C-Oil Spilled in the Marine Environment

Of the approximately 22 million barrels of petroleum hydrocarbons entering the marine environment, about 37 percent comes from industrial, municipal, urban, and river runoff; about 34 percent from tanker operations and accidents; about 12 percent from other shipping accidents and sources; about 8 percent from natural sources; and about 2 percent from offshore petroleum production.

To date, the world's largest spill occurred in 1978 when the *Amoco Cadiz ran* aground off the coast of France and spilled 68 million gallons of crude oil along about 250 miles of shoreline. The largest recent blowout occurred near the Mexican coast during a 10-month period in 1979-80, discharging over 125 million gallons of crude oil into the Gulf of Mexico.

SOURCE: *Oil in the* Sea. *Inputs, Fates, and* Effects (Washington, DC: National Academy Press, 1985), pp. 82,561.

Table 5-2-(Oil Spill Probabilities for the Navarin Main, Bering Sea (per billion barrels of oil produced)

	Number of oil spills (by size)	
Source of spill	(>1 ,000 barrels)	(>10,000 barrels)
Platform	1.0	0.4
Pipelines	1.6	0.7
Tankers at sea . . .	0.9	0.5
Tankers in port . . .	0.4	0.2
Total	3 . 9	1.8

SOURCE: Minerals Management Service, Navarin Basin Lease Offering. Final Environmental Impact Statement, November 1983.

cost to replace equipment destroyed by fire may ultimately be less than the cost to clean up the environment. Burning also produces air pollution and a bum residue and thus could have negative impacts on, for example, birds and seal rookeries during the summer breeding season. Considering the alternative of letting the oil reach sensitive areas, burning may still be appropriate in some circumstances.

3) **Mechanical Recovery:** Over the last two decades considerable effort has gone into developing surface booms and water jets to limit the spread of oil spills, and surface craft to mechanically skim and collect oil from floating slicks.[51] Such equipment, however, has its limitations even under the best of circumstances. Most currently available skimmers are incapable of cleaning up large amounts of spilled oil. Historically, skimmers have rarely been able to recover more than 10 percent of the oil from any large spill. In Antarctica, the performance of most oil recovery equipment would be adversely impacted by high winds, large waves, strong currents, cold temperatures, and ice. Any recovered oil would also have to be disposed of, possibly by landfilling or by incineration in air-transportable units.

Mineral Exploration and Mining Activities[52,53,54,55,56,57]

Chapter 4 indicates that the potential for recovering hard minerals from Antarctica is for the most part unknown. However, the mining of high-grade mineral deposits in ice-free areas of the Arctic has been underway for the past two decades. (See app. B.) For example, COMINCO operates a year-round, lead-zinc mining operation on Canada's Little Cornwallis Island about 600 miles north of the Arctic Circle. Open pit or underground mining operations of this sort typically involve considerable drilling, blasting, and the generation of rock waste, dust, and noise. Ore processing (e.g., crushing, grinding, and flotation) typically requires substantial amounts of energy and water, and generates large volumes of mill

[51] The largest skimmer in the Arctic is a 65-foot single-purpose, catamaran that use-s continuously moving, absorbent, polypropylene rope to sop up oil; under actual operating conditions recovery rates could range from about 5 barrels (e.g., about 150 gallons) to about 30 barrels (i.e., almost 1,000 gallons) per hour.

[52] M. Magee, ' 'A-merit of Mining and Process Technology for Antarctic Mineral Development-Volume I," OTA contract report, January 1988, p. 114.

[53] Rutford, op. cit., footnote 7, pp. 33, 58, 45, 46.

[54] Elliot, op. cit., footnote 6, pp. xiii, xv-xvi, [v-7, 12, 17, 18, V-1 to 19, VII- I to 4, 8,9.11 to 16, IX-~* 2.

[55] Zumberge, op. cit., footnote 8, pp. 23-25, 36, 44-45.

[56] Zumberge, op. cit., footnote 41, pp. 143-144.

[57] U.S. Department of State, op. cit., footnote 42, pp. 6-11 to 6-18.

tailings and other wastes. Any ores mined in Antarctica would probably be shipped off-site for smelting.

Impacts on terrestrial flora and microfauna in the immediate vicinity of these mining and ore processing activities should probably be considered permanent total natural recovery of adjacent areas would require many decades to a few centuries. The physical disturbance (e.g., modification of terrain, destruction of soil **and** wet permafrost) and/or chemical pollution (e.g., accidental spills of fuel oil and other chemicals, etc.) from mining, ore processing, and associated construction activities in Antarctica will likely impact soils, ice-rich permafrost, and the terrestrial ecosystem (e.g., mosses and lichens) in the vicinity of mining operations. However, **mining operations are unlikely to occur on a large enough scale to pose a significant threat to the overall terrestrial ecosystem of Antarctica.**

The most significant potential impacts from mining operations in Antarctica would probably be associated with the disposal of mill tailings from ore processing and any subsequent leaching of heavy metals from such tailings.[58] Mill tailings could conceivably be disposed in the ocean, in inland lakes, in abandoned parts of the mine, in specially designed dammed or diked containment areas in ice-free regions, or perhaps on the ice. Land disposal of tailings and the subsequent treatment of any discharged water to meet stringent environmental standards is technically feasible, but often quite expensive.

The potential for mining Antarctic mineral deposits raises concerns about competition between mining activities scientific research, tourism, and wildlife for ice-free terrestrial environments. Seals and sea birds using the coastal environments surrounding Antarctica would be disturbed by noise from mining and associated kind-based development activities located near breeding grounds, congregating areas, or migratory corridors. Marine organisms would also be adversely impacted by accidental spills of chemicals and oil. Any areas of the marine ecosystem that might be locally impacted by mining activities would probably recover naturally; total recovery, however, could require several decades.

Scientists have speculated that the production and settling of dust from large-scale mining and construction activities in Antarctica could decrease the highly reflective character of its snow-covered areas.[59] However, volcanic ash that has been widely dispersed over large areas of Antarctica by past eruptions apparently had no such effect. Instead, these layers are apparently quickly buried by subsequent snowfalls.[60]

Dredging With Open-Water Disposal of the Dredged Material[61] [62] [63]

The construction of docking facilities along Antarctica's coast may require the dredging of nearshore areas and the subsequent disposal of the dredged material, presumably in open-water areas. Some dredging may also be required to bury pipelines from underwater wellheads, or perhaps to mine offshore placer deposits.[64] It is also conceivable that mill tailings from land-based mining operations could be disposed in nearshore marine environments, thereby generating impacts similar to those produced when dredged material is disposed in open-water environments.

Turbid plumes of fine-grained suspended material are usually found within a few hundred to several hundred feet of most dredging and open-water disposal operations. Such turbidity will decrease phytoplankton photosynthesis and may adversely

[58] M. Magee, op. cit., footnote 52, p. 114.

[59] "Albedo" is the fraction of incoming light or radiation that is reflected. Snow-covered areas have a high albedo; dark surfaces that absorb incoming radiation have low albedos.

[60] Zumberge, op. cit., footnote 41, pp. 134-136.

[61] U.S. Congress, Office of Technology Assessment, *Wastes in Marine Environments*, OTA-O-334 (Washington, DC: U.S. Government printing Office, April 1987), pp. 243-246.

[62] U.S. Congress, Office of Technology Assessment, *Marine Minerals: Exploring Our New Ocean Frontier, OTA-342* (Washington, DC: U.S. Government printing Office, July 1987), pp. 215-223, 233-236.

[63] Elliot, op. cit., footnote 6, pp. VII-4, 5, 13, 14.

[64] Placers are deposits of minerals—either dispersed or locally concentrated in lenses—found within unconsolidated sands and gravels.

affect growth and reproduction of some pelagic organisms. However, field studies of dredging and disposal operations around the United States indicate few detectable physical impacts from water column turbidity; any chemical releases (i.e., manganese, iron, ammonia, and phosphorus) are rapidly diluted. Turbidity plumes typically dissipate within several hours after dredging and/or disposal operations cease.

Benthic organisms in dredged areas around Antarctica will likely be destroyed by most types of dredging equipment. In addition, at open-water disposal sites, most benthic organisms that are covered by more than a foot or so of dredged material will be suffocated. At disposal sites in a few tens of feet of water, such accumulations of dredged material are usually resticted to bottom areas within several hundred feet of the point from which the dredged material is discharged into the water column. In deeper water, the bottom area covered by dredged material will increase, but the thickness of accumulating material will decrease.

Recolonization of dredging and disposal sites by benthic organisms in temperate marine environments usually begins within a period of weeks after cessation of the disposal operation; extensive recolonization can take from several months to a few years in temperate climates. However, recolonization of Antarctic benthic environments may require considerably more time due to the colder temperatures.[65]

Development ofSuppotiFacil&"e@667 and Transportation Systems[68]

The development of support facilities and transportation systems would lead to the destruction or modification of Antarctic flora and fauna on a local scale, similar to those described in the previous section on mining activities. These types of activities will also compete with wildlife for ice-free terrestrial environments.

Oil and/or minerals development in Antarctica would involve constructing living quarters, oil storage tanks, mineral processing units, power generating stations, water and sewage treatment plants, fuel storage facilities, buildings for storage of equipment and supplies, etc. Developing and operating an average-sized mine or an oil field would require a few hundred personnel and support staff working at least 200 days per year over the life of the activity. Construction activities would involve quarrying rock and/or dredging sand and gravel for concrete and roads, modifying terrain, and installing surface and subsurface drainage. Accidental spills of fuel and other chemicals are also inevitable. Support activities will also generate wastes in the form of obsolete equipment, sewage and wastewater, biodegradable food, and other litter.

If oil or mineral resources in Antarctica are eventually developed, the existing transportation system (e.g., roads, air fields, docks and harbors, etc.) used to supply scientific research bases would have to be expanded. Additional ships, roads, railroads, vehicles, and/or pipelines would also be required to remove any resources. For example, an oil recovery operation for a 4-billion-barrel field probably would require special storage facilities and a few dozen specially built ships and docking facilities to remove the oil during the summer months. Some scientists also believe that oil discharges from routine tanker loading and from tanker accidents could have significant cumulative impacts on the Antarctic marine environment at a local and perhaps regional level.

IMPACTS FROM MAN'S PAST ACTIVITIES

Scientific Research Bases

During the 1800s and early 1900s, two dozen exploratory expeditions from various countries visited Antarctica. Since the early 1900s, about 80 temporary and/or permanent research bases have been established there. The first modern, internationally coordinated scientific effort to study the region occurred during the 1957-58 International Geophysical Year, during which 50 research stations

65 Zumberge, op. cit., footnote 8, p. 38.

66 Elliot, op. cit., footnote 6, pp. xvii, Vii-2 to 11, 19, 20.

67 Zumberge, op. cit., footnote 8, pp. 28, 31-32.

68 Rutford, op. cit., fcmt.note 7, p. 52.

were maintained by 12 countries,[69] The 48 year-round and 19 summer research bases operated by about 18 nations are shown in figure 5-6.[70] Three year-round bases are American.

Waste disposal practices in Antarctica during the 1950s, 1960s, and early 1970s were characterized by a lack of state-of-the-art disposal alternatives (e.g., incinerators, sewage treatment plants, etc.) and by a "frontier" attitude toward the environment. Since the mid-1970s most countries have become more aware of environmental impacts. With the exception of the oil spill from the *Bahia Paraiso* sinking, most impacts can be traced to accidental releases of small amounts of oil and other chemicals, the construction and operation of research bases and field camps, and the disposal of wastes. Some environmental groups contend that waste disposal practices (e.g., open burning and landfilling) could be improved significantly with the use of different technologies. Such technologies are often more costly.

Pollution in the immediate vicinity of most year-round research bases has probably killed or significantly impacted some or all benthic marine organisms. For example, oil in the sediments of Winter Quarters Bay, McMurdo Sound has largely eliminated all benthic organisms. However, benthic populations a few hundred meters beyond these localities do *not* appear to have been significantly impacted.[71] **Considering Antarctica's vast size, the impacts generated by past scientific research activities would be considered by most people to be insignificant; some environmentalists, however, view them as more serious.**

In recent years many countries have begun cleaning up their research bases in Antarctica. For example, in the 1986-87 season, the cargo ship *M/V Green Wave* took 1,700 tons of waste back to the United States for recycling and/or disposal. In 1988

Photo credit: Ann Hawthorne

Adelie penguins near McMurdo.

NSF outlined a $30 million, 4-year cleanup program for American bases in Antarctica, and established an Environmental Protection Agenda for all future federally supported activities in Antarctica.[72]

Since the late 1950s, about two dozen coastal bases have been abandoned or used only occasionally, often by expeditions from several different countries. In many cases, equipment, buildings, food, fuel drums, and much litter have been left behind. Assuming responsibility for cleaning up these abandoned bases could be difficult, especially those bases used by more than one country .73

Tourism[74,75,76,77]

Small air charters and expedition-type cruises on ships carrying up to 150 tourists have become increasingly popular over the last 25 years. Most tourists visit the Antarctic Peninsula. There is a 100-bed guest house and a bank for visitors to Chile's Teniente Marsh research base on King George Island off the Antarctic Peninsula. Over the next few years it is anticipated that two to three

[69] Central Intelligence Agency, op. cit., footnote 5, p. 40.

[70] S.R. Fletcher, "Antarctica: Environmental Protection Issues, Congressional Research Service Report for Congress, 89-272 ENR, Apr. 10, 1989, p. 11.

[71] Robilliard, op. cit., footnote 46, pp. 937-944.

[72] National Science Foundation, Division of Polar Programs, "U.S. Antarctic Program: Environmental Protection Agenda," Aug. 31, 1988, p. 45.

[73] Greenpeace, "1987-88 Greenpeace Antarctic Expedition Report,' Stichting Greenpeace Council, United Kingdom, p. 80.

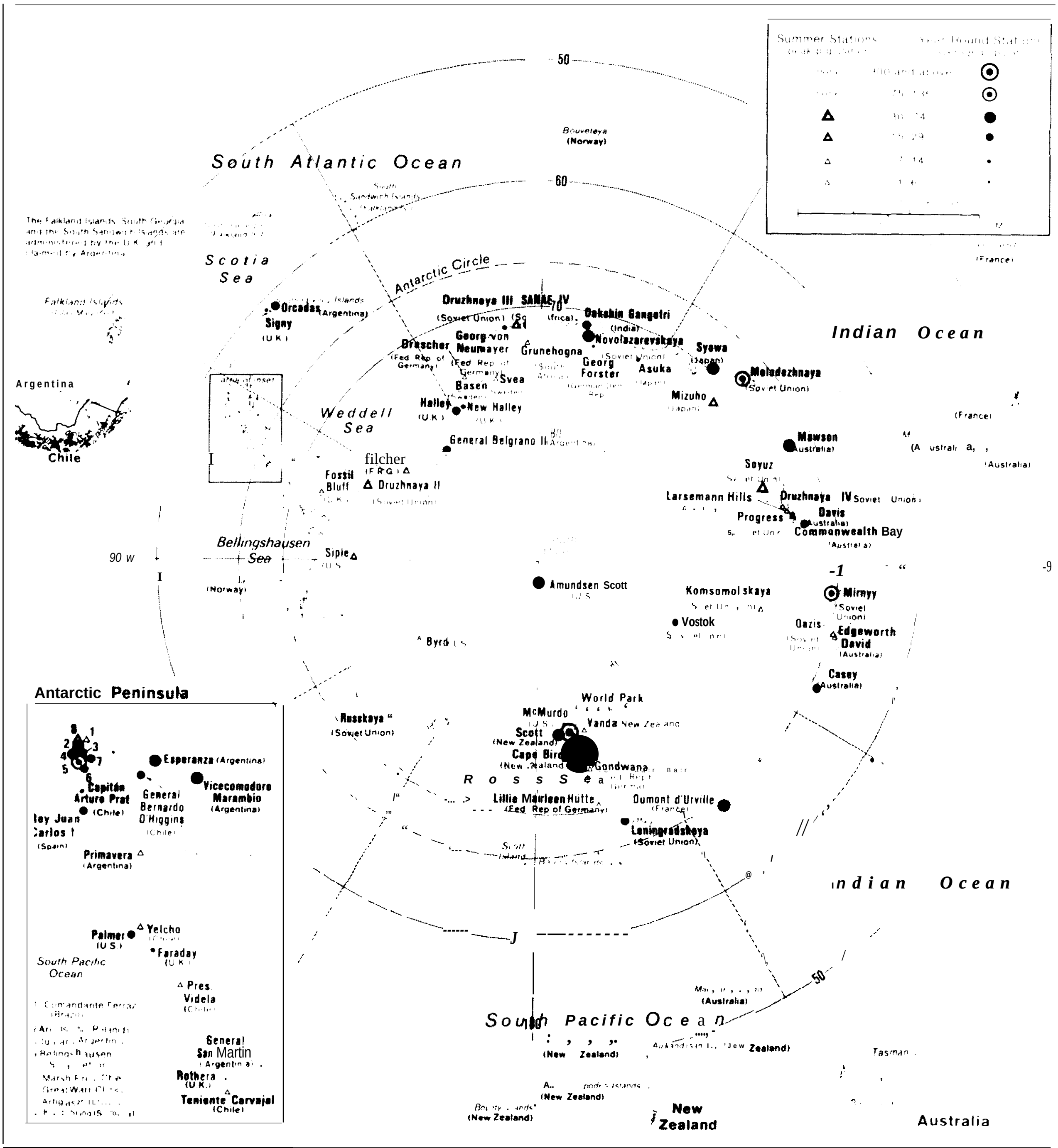
[74] P.D. Hart, "The Growth of Antarctic Tourism," *Oceanus*, vol. 31, No. 2, Summer 1988, pp. 93-100.

[75] National Science Foundation, *Safety in Antarctica*, NSF 88-78, 1988, pp. 9-1 to 9-10.

[76] F.M. Auburn, *Antarctic Law and Politics* (Bloomington, IN: Indiana University Press, 1982), pp. 277-283.

[77] Fletcher, op. cit., footnote 70, P. 57.

Figure 5-6-Research Stations on Antarctica



SOURCE: U.S. Government, 1989.

dozen tours-bringing about 3,500 people annually—will visit Antarctica. Many tour groups are well-informed and well-supervised; some are not.

Table 5-3 provides data on the approximate number of person-days spent in Antarctica by tourists and scientists. These figures indicate that scientists and their support staff account for about 95 percent of the person-days logged in Antarctica. The relative impact of tourist-related activities is probably much less than these figures indicate, since land-based facilities are usually not required to support tourist groups. In other words, the environmental impacts associated with normal tourist activities are at present minor compared to the impacts generated by research activities. The recent sinking of the *Bahia Paraiso* is an important exception to this generalization. However, if tourism increases and remains largely unregulated, the potential for adverse impacts will increase.

Harvesting of Fish, Seals, and Whales

The most significant impacts to the marine ecosystem of the Southern Ocean surrounding Antarctica have been generated by overharvesting of fish, fur seals, and five species of whales.

Antarctic Fishing

Major interest in Antarctic fishing developed initially during the 1960s, and expanded significantly during the 1970s. For example, fish catches increased from about 4,000 metric tons in the early 1970s to a peak of about 500,000 metric tons in the 1979-80 season, relative to almost 100 million metric tons worldwide. The Antarctic cod was the initial target of commercial fisheries in the early 1970s, but because of declining catches the focus shifted to ice fish toward the end of the 1970s. Both species are now depleted. Krill harvests increased from about 2,000 metric tons in 1973 to about 446,000 metric tons in 1986.[78]

The **Convention on the Conservation of Antarctic Marine Living Resources** (CCAMLR) was negotiated in response to heavy fishing, the consequent depletion of fish stocks in the 1970s, and concerns about the possible development of a krill fishery. It entered into force in 1982 and applies to offshore areas within about 1,000 miles (1,600 km) of Antarctica.[79,80,81,82] The United States implemented this convention in 1984 through passage of the **Antarctic Marine Living Resources Convention Act** (Public Law 98-623). The Convention encourages the study, management, and conservation of the living resources within Antarctica's *overall* marine ecosystem, rather than focusing on individual species of commercial importance.

Seal Harvesting

In the late 1700s and the early 1800s sealers from the United States, Russia, and other European countries began harvesting seals around the islands in the Southern Ocean near Antarctica. Over 1 million seals were killed around South Georgia (in the South Atlantic) alone between 1820 and 1822.[83] Uncontrolled slaughter of fur seals for their thick fur brought this species close to extinction by 1830. The harvest of elephant seals for blubber oil began in the early 1800s and continued until the 1960s. The four species of seals (i.e., crabeater, Weddell, leopard, and Ross) that only inhabit Antarctica have remained largely untouched by sealers due to their inaccessibility or poor fur quality.[84]

After some limited harvesting of seals in 1964, the then 14 parties to the Antarctic Treaty drew up the **Convention for the Conservation of Antarctic Seals,** which was signed in 1972 and entered into

78K. Sherman and A.F. Ryan, "Antarctic Marine Living Resources," *Oceanus, vol.* 31, No. 2, Summer 1988, pp. 59-63.

79Ibid., pp. 59-63.

80R.J. Hofman, "Conservation of Marine Living Resources in Antarctica, unpublished paper for Seminar on the Polar Regions, Center for Oceans Law and Policy, University of Virginia, Charlottesville, VA, March 1987, p. 14.

81J.N. Barnes, "The Emerging Convention on the Conservation of Antarctic Marine Living Resources: An Attempt to Meet the New Realities of Resource Exploitation in the Southern Ocean,' J.I. Charney (d.), *The New Nationalism and the Use of Common Spaces: Issues in Marine Pollution and Exploitation of Antarctica* (Totowa, New Jersey: Allenheld, Osmun publishers, 1982), pp. 239-286.

82Signatory nations to CCAMLR include the principal fishing countries of the world including Japan with 13 percent of the world's catch, the Soviet Union with 12 percent, China with 8 percent, and Chile and the United States with 6 percent each.

83H.J. Sutton and P.K. Park, "UNEP and Antarctica" (draft), United Nations Environment Programme, Nairobi, Kenya, August 1988, p. 20.

84Central Intelligence Agency, op. cit., footnote 5, p. 51.

Table 5-3-Presence of Scientists and Tourists on Antarctica

	Approximate populations	Duration of stay in days	Person-days	Percent of total
Scientists and support personnel (UNEP):				
Summer (@ 67 bases)	3,500	120	420,000	
Remaining 8 months (@ 48 bases)	1,000	240	240,000	
(subtotal)			660,000	95%
Tourists	3,500	10	35,000	5 %
Total ., ...			695,000	

SOURCE S.R Fletcher. "Antarctica. Environmental Protection Issues." Congressional Research Service Report for Congress, 89-272 ENR, Apr. 10, 1989, p. 57.

force in 1978. The Convention totally protects the fur, elephant, and Ross seals from exploitation; prohibits the taking of seals that are **in the water (except in limited numbers for scientific purposes);** and sets annual quotas, seasons, and capture zones for crabeaters, leopards, and Weddell seals.[85 86] The enforcement of the agreed-upon conservation measures depends entirely on the self-policing policies of the signatory nations.

Whaling

Whaling around Antarctica began around the turn of the century, From the late 1920s and early 1960s, the world's principal whaling grounds were located in the Southern Ocean within about 600 to 1,200 miles of Antarctica. Particularly because of the introduction of explosive harpoons, harpoon cannons, motorized catcher boats, and large factory ships in the late 1920s, Antarctic whalers caused critical declines in the populations of right, blue, humpback, fin, and sei whales. Since the early 1960s more than 1 million whales have been killed in Antarctic waters.[87] (See table 5-4.[88])

Voluntary limits on whaling were established by the International Convention for the Regulation of Whaling during the 1930s.[89 90 91] These limits had little effect. In 1946 the International Whaling Commission (IWC) was established to regulate the whaling industry worldwide; its recommendations did not carry much weight until the late 1960s. In **1986** the IWC instituted a temporary moratorium on all commercial whaling; this moratorium is scheduled for review in the near future. As might be expected, there are differing views within the IWC about the exploitation of whales and how whaling should be managed.[92]

Avoiding Sensitive Areas and Rehabilitating Impacted Areas

Unique and/or especially sensitive areas should be avoided, to the extent possible, in any future Antarctic minerals exploration and development. For example, highly stratified saline lakes found in East Antarctica are especially susceptible to impacts in the summer when streams flow along adjacent ice-free valleys into them.[93] The Treaty Parties have set aside 28 Specially Protected Areas (SPAS) where research, plant and animal collection, and vehicular access are denied without entry permits. Due to their importance for scientific research, 17 other sites have been designated Sites of Special Scientific Interest (SSSIs). These areas are off-limits to visitors

[85] Siniff, op. cit., footnote 21, pp. 71-74.

[86] Hofman, op. cit., footnote 80, p. 14.

[87] Ibid., p. 14.

[88] D.C. Chapman, "Living Resources: Whales, " *Oceanus*, **vol.** 31, No. 2, Sumner 1988, pp. 64-70.

[89] Ibid., pp. 64-70.

[90] Central Intelligence Agency, op. cit., footnote 5, pp. 52-53.

[91] J. Gulland, "The End of Whaling?" *New Scientist*, vol. 120, No. 1636, Oct. 29, 1988, pp. 42-47.

[92] Hofman, op. cit., footnote 80, p. 14.

[93] Zumberge, op. cit., footnote 8, pp. 24-25.

Table 5-4-Worldwide Populations of Whales Commonly Found In the Southern Ocean

species	Average adult size (in m)	Population (in thousands)[a]		
		Original world	Current world	Antarctic
Southern Right	12	100	3	3
Blue	23	228	14	11
Humpback	11	115	10	3
Fin	19	548	120	100
Sei	13	256	54	37
Sperm	12	2,400	1,950	950
Minke	7	140	725	380

[a]All estimates are highly speculative.

SOURCE: Most data from the International Whaling Commission, *Oceanus*, vol. 32, No. 1, Spring 1989, pp. 12-13. Data on Antarctic stocks from P.G.H. Evans, *The Natural History of Whales and Dolphins* (London: Christopher Helm, 19S7), p. 343.

and access must conform to a management plan for each SSSI. The locations of SPAS and SSSIs are shown in figure 5-7.

Much can be done to clean up previously used scientific research bases or resource development sites in Antarctica by removing garbage, unused fuel, **chemicals,** and other potentially toxic waste. However, it is not possible or practical to accelerate the natural recovery of impacted upland areas or marine environments to their original conditions. Future human activities should therefore be planned and designed to minimize potential impacts in the first place.

REGIONAL AND GLOBAL IMPACTS FROM ANTARCTIC DEVELOPMENT[94][95]

The larger the scale of mineral development in Antarctica, the greater will be likely long-term regional impacts on terrestrial and marine ecosystems. Some of these would undoubtedly take the form of ill-defined sublethal and chronic effects on the terrestrial and marine ecosystems from low levels of contamination. Furthermore, **the more Antarctica is polluted by regional sources, the less useful the continent becomes for evaluating the effects of global pollution on the world's oceans and atmosphere.[96] However, available information suggests that resource development in Antarctica, even if pursued on a large scale, would probably not generate significant global impacts to the world's oceans and atmosphere relative to other activities of man,[97]**

Scientists would probably be especially concerned about the potential impacts of resource development occurring within or near designated research areas. As illustrated by the recent sinking of the *Bahia Paraiso,* oil spills probably represent the greatest risks to Antarctic research, especially biological and ecological research. The majority of nonbiological research in Antarctica would probably not be directly impacted by development activities; however, there would be indirect impacts from added logistics activities, land-based construction, and possible disruptions caused by accidents.

Research Required to Better Predict Impacts[98][99][100][101][102]

Scientific exploration of Antarctica began in the early 1800s with several biological investigations.

[94]U.S. Department of State, op. cit., footnote 42, pp. 6-26 to 6-28.

[95]Zumberge, op. cit., footnote 41, pp. 115-154.

[96]Rutford, op. cit., footnote 7, pp. 34-35.

[97]Zumberge, op. cit., footnote 8, pp. 33, 44-46.

[98]Rutford, op. Cit., footnote 7, pp. 10, 36-3'7, 43, 53-55, 67.

[99]Elliot, op. cit., footnote 6, pp. xviii, VIII-1 to 4.

[100]U.S. Department of State, op. cit., footnote 42, pp. 6-28 to 6-31.

[101]Holdgate, op. cit., footnote 91 pp. 38-48.

[102]Charney, op. cit., footnote 2, pp. 214-215.

Photo credit: *Ted DeLaca,* National Science *Foundation*

Palmer station, Anvers Island, off the Antarctic Peninsula. Areas in the vicinity of Palmer station were impacted by the Bahia Paraiso spill.

Geologic exploration of the continent began in the late 1800s. Numerous scientific expeditions during the 1900s continued to increase our knowledge about the Antarctic environment. The establishment of 50 bases by 12 countries during the International Geophysical Year in 1957 and 1958 transformed Antarctica into an international scientific laboratory.

Despite continuing research there are still significant uncertainties about the environment of Antarctica. As described in chapter 4, the geologic data is meager for accurately estimating Antarctica's mineral potential. The response of the continental ice sheet and surrounding seasonal sea ice to changing climatic conditions is poorly understood. More quantitative data is required to better understand the ocean circulation around Antarctica, especially during the winter and in coastal waters. Weather forecasting is still difficult. Floral and faunal distributions on the ice-free coastal areas are fairly well documented, although the ecosystem relationships are not well understood. Baseline data on the marine ecosystem are still incomplete, including information on biomass distributions, productivity, and food web relationships.

It is generally believed by both industry representatives and environmentalists that minimizing the possible impacts of resource development activities will be difficult without first collecting additional environmental information on the topics listed in table 5-5. Furthermore, a better understanding of Antarctica's environment, particularly the marine ecosystem, is necessary in order to evaluate the significance of impacts generated by development activities relative to natural variability and other independent trends, such as fishing. In fact, Article 4 of the Convention stipulates that no mineral exploration or development will be allowed without adequate information about the potential impacts that such activities might generate.

The Federal Government has spent about $200 million over the past 15 years to evaluate potential impacts of oil and gas development on the continental shelf of the United States. The environmental research required before and during offshore petroleum development in Antarctica could cost as much as a few hundred million dollars.[103] An additional *$200* to *$300* million could also be required for an ice-strengthened research ship for marine research. The research required to evaluate the impacts associated with minerals development and other land-based activities could be less costly than marine research. As in other expensive, large-scale scientific endeavors, the United States could seek to defray some of these costs through an international cooperative effort.

The Convention describes the general requirements and procedures for evaluating potential environmental impacts that will be associated with exploration and development activities. However, it is not clear in the Convention text whether the research in table 5-5 would be conducted and paid for by the Operator or by the Sponsor.

[103] Research in Antarctica might cost more or leas than this amount. On the one hand, research would probably not have to include the continent's entire coastline and continental shelf. On the other hand, research in Antarctica probably costs about two or three times more than comparable research on the U.S. continental shelf due to the continent's remote location, greater logistical requirements, and adverse working conditions. Also, impact assessments could be more costly if the study areas are more variable or complex than assumed. Based on NSF's funding figures for scientific research in Antarctica (noted at the end of this chapter's introduction), the international community has probably sponsored several tens of millions of dollars of research on the topics listed in table 5-5 over the last two decades.

Figure 5-7-Specially Protected Areas and Sites of Special Scientific Interest on Antarctica

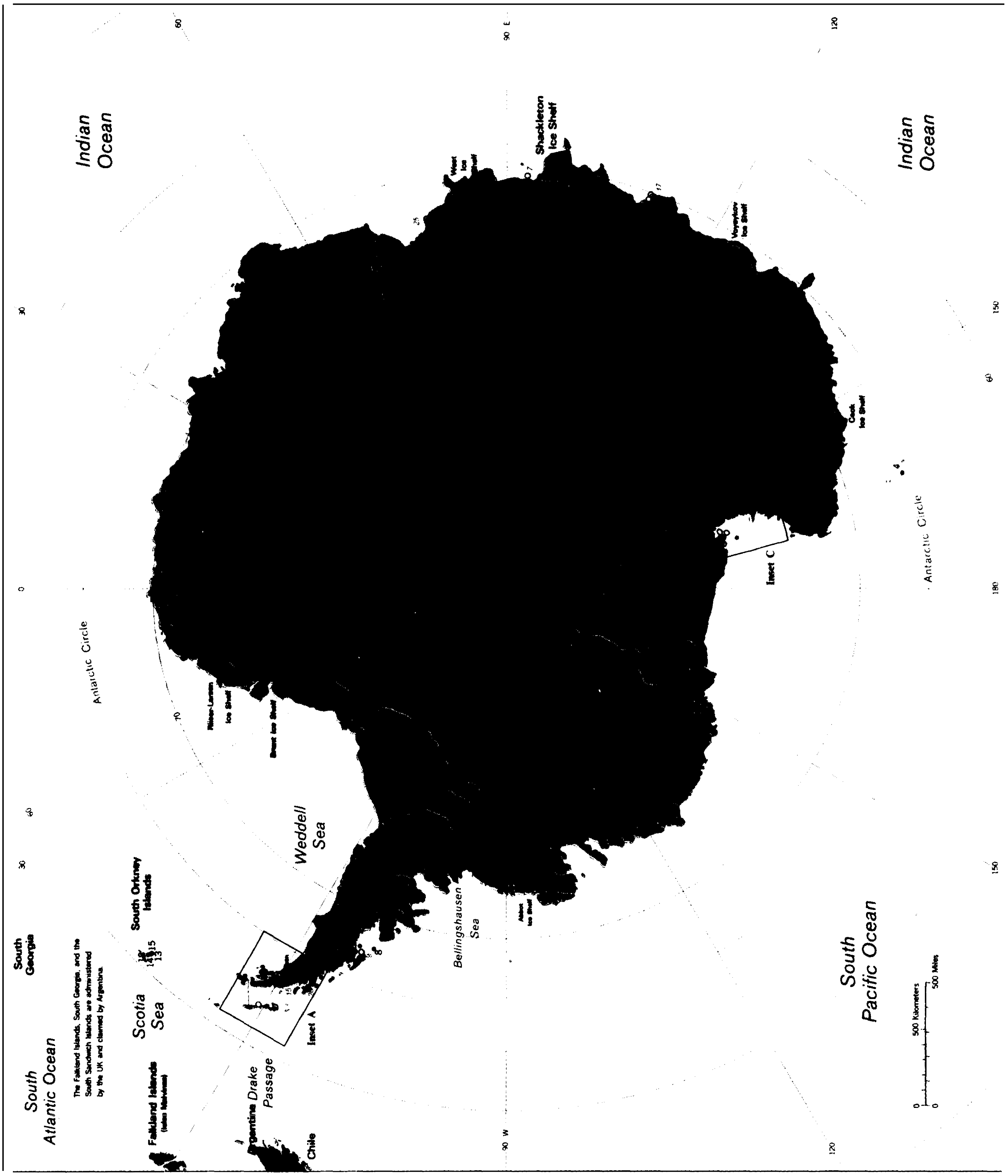
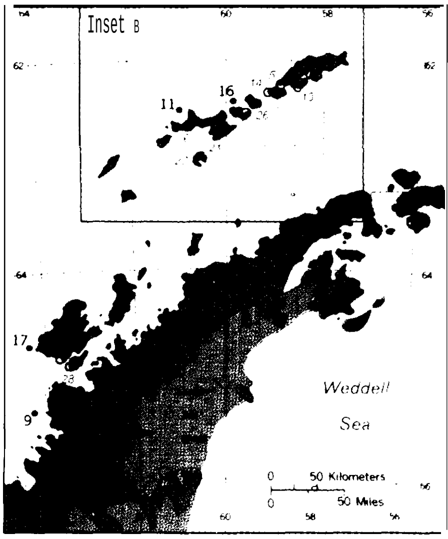
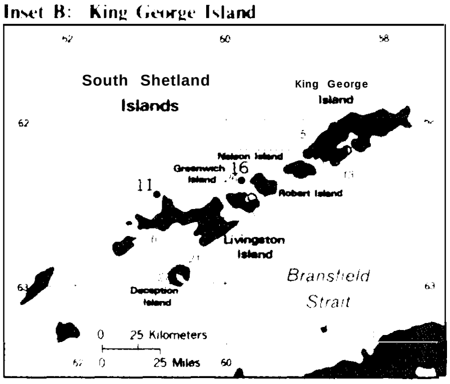


Figure 5-7-Specially Protected Areas and Sites of Special Scientific Interest on Antarctica-Continued

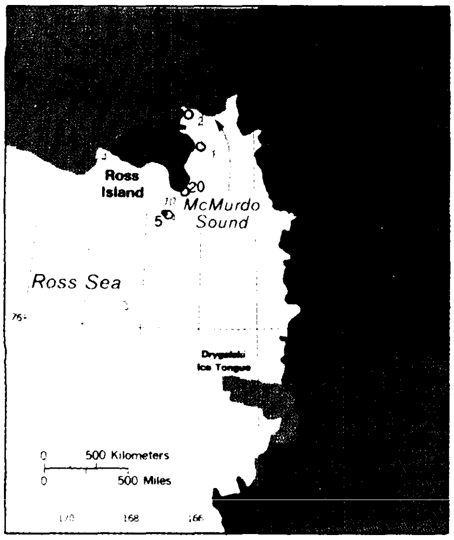
Inset A: Antarctic Peninsula



Inset B: King George Island



Inset C: Ross Sea



Sites of Special Scientific Interest

1. Cape Royds
2. Arrival Heights
3. Barwick Valley
4. Cape Crozier
5. Fildes Peninsula
6. Byres Peninsula
7. Haswell Island
8. W. shore of Admiralty Bay
9. Rothera Point
10. Caughley Beach
11. Tramway Ridge
12. Canada Glacier
13. Potter Peninsula
14. Harmony Point
15. Cierva Point
16. Bailey Peninsula
17. Clark Peninsula
18. White Island
19. Linnaeus Terrace
20. Biscoe Point
21. Shores of Port Foster
22. Yukidori Valley
23. Svarthamaren
24. Summit of Mt. Melbourne
25. Marine Plain
26. Discovery Bay
27. Port Foster
28. South Bay

Specially Protected Areas

1. Taylor Rookery
2. Rookery Islands
3. Ardery and Obert Islands
4. Sabrina Island
5. Beaufort Island
6. (now site of special scientific interest 4)
7. Cape Hallett
8. Dion Islands
9. Green Island
10. (now site of special scientific interest 6)
11. Cape Shirreff
12. (now site of special scientific interest 5)
13. Moe Island
14. Lynch Island
15. Southern Powell Island
16. Coppermine Peninsula
17. Litchfield Island
18. North Coronation Island
19. Lagotellerie Island
20. New College Valley

SOURCE: U.S. Government, 1989.

Table 5-5-Basic Research Required to Evaluate Possible Environmental Impacts Prior to Resource Development

Research and Information requirements

- more detailed data on terrestrial, lacustrine, and marine ecosystems, especially those areas that are most likely to be considered for resource development, and those areas that are judged to be most sensitive to impacts
- content and composition of hydrocarbons and other contaminants In Antarctic waters. sediment. and marine organisms

Research requiring extended time-series measurements (e.g., over a decade)

- marine and terrestrial ecosystem dynamics in response to pollution and other impacts from potential resource development
- fate of oil and its degradation in open and ice-filled seas around Antarctica,, and under-shelf ice
- adverse short- and long-term effects (e.g., toxicity) of oil on Antarctic phytoplankton, krill, seals, and benthic communities

SOURCE: Office of Technology Assessment, 1989.

Chapter 4 contains a discussion of research required to evaluate the mineral resources of Antarctica. Appendix A presents an oil development scenario and discusses research needed on geologic hazards, weather, and ice movement prior to the development of petroleum resources in Antarctica.

Monitoring and environmental baseline studies will become increasingly important if minerals activities commence in Antarctica. The United States could be at a disadvantage in Minerals Convention meetings if it does not devote more attention to this type of work.

Appendixes

Photo credit: *U.S. Geological Survey*

Appendix A
Development of an Antarctic Oil Field

INTRODUCTION

This appendix was prepared to illustrate the most likely hypothetical scenario that would be employed if an Antarctic oil field were developed under the terms of the new Minerals Convention, It explores the technological capabilities and economic incentives that would determine the viability of a hypothetical Antarctic oil field and presents some possible approaches to development. If commercial quantities of oil are discovered in Antarctica in the future, companies experienced in developing offshore fields in harsh, Arctic environments today would, in some situations, have the capability and may also have the incentive to develop an Antarctic field, Whether they ***would*** have the capability depends on both specific environmental conditions where the field is located and the future status of needed technologies. Whether companies *would* have the incentive depends on profitability and risk-both financial and political.

The scenario presented in this appendix is based on admittedly optimistic assumptions about several determining factors. Three are key to the discussion:

-*first*, that a world-class giant field is discovered;

—second, that the parties to the Minerals Convention allow oil development in the area *in* which the field is located and assure the developer of rights to produce the field; and

—***third,*** that the world price of oil is and remains high enough to make Antarctic production economics attractive,

Some of the needed technology for selected Antarctic oil development has been built and is now successfully employed in other areas; other technology must be assumed to be available in the future as a consequence of oil field ventures in other harsh environments. These assumptions may or may not be realized in the future. If any condition is not met, an Antarctic oil prospect would probably not be developed. If the assumptions hold, however, it is not unreasonable to project that over time, the needed technology will be available and certain prospects will be profitable to develop.

An Antarctic oil venture could not be undertaken before the turn of the century. Substantial lead times will be needed to do further scientific resource assessment work, environmental baseline work, and surveys of physical environmental constraints. Following this work, substantial time must be devoted to reconnaissance surveys. At the same time the regulatory system will require preparation of exploration and development plans and evaluation of environmental impacts. Finally, long lead times will be needed to identify any oil field through exploratory drilling, to delineate that field through additional drilling, and to design and construct a production and transportation system. OTA concludes that the minimum total time elapsed before any major Antarctic field could be expected to produce oil would be 30 or more years from today.

The technology needed for Antarctic oil development in certain offshore regions is not substantially different from that under development or available to major firms for the Arctic and deep water temperate regions. For Antarctic regions with more severe conditions, it is not unreasonable to expect new technology to be available over the next few decades. Much of the needed research and development work is now underway. It is also reasonable to expect that the world oil price will rise sufficient y to make Antarctic oil production profitable in the next three to five decades, even though the current plentiful world supply may continue. Technology appears to be one of the lesser important constraints to future Antarctic petroleum development. Political, institutional, and environmental constraints appear more significant.

The following sections discuss a purely hypothetical development that might take place at a time at least 30 years in the future. Such a long range projection must contain a large amount of uncertainty, but it is necessary to look this far in the future in order to consider what development might be like under the new Minerals Convention. At the present state of knowledge and institutional maturity it would be unreasonable to expect commercial oil development to occur much sooner.

The following sections present:

. the design environment for Antarctic offshore oil development
. a discussion about technologies that may be used for Antarctic production; and
. a hypothetical scenario for Antarctic development.

THE DESIGN ENVIRONMENT FOR ANTARCTIC OIL DEVELOPMENT

The discussion in chapter 4 shows that the greatest potential for Antarctic oil development exists in one of the offshore sedimentary basins, such as that in the Ross Sea, that OTA selected for its hypothetical scenario. The environmental conditions that determine the major design criteria for development systems are quite severe in any

Antarctic offshore region, and the Ross Sea is no exception. The significant factors include:

- glacier ice (the origin of icebergs);
- sea ice (single-year ice 3 to 6 feet thick);
- icebergs (some very large-to tens of miles square);[1]
- extreme cold (annual mean temperature 0°F along coastline);
- heavy seas (frequent, severe storms);
- deep water (2,000 to 3,000 feet in Ross Sea);
- long periods of winter darkness;
- possible frozen gas hydrate present subsea;
- deep water iceberg scour (up to 1,500 feet);
- active faulting; and
- sea-bottom permm.frost

While the available data are sufficient to make the above list and identify the importance of these factors overall, much more data will be needed to set design criteria for any future oil production system. If oil development is expected to take place in the next century, it will also be necessary to spend considerable time and effort collecting information and analyzing environmental design conditions. Some of these data requirements are shown in box A-1. One of the most important areas where existing information is lacking is that of size and frequency of icebergs. Icebergs could be a major design constraint for specific production platforms. Other information, such as of deep currents, sea ice anomalies, etc., could also be potentially important but very few data are available to make a judgment.

Based on current knowledge of the Antarctic environment, ice appears to be the most significant factor in the above list both because very severe iceberg conditions are known to exist in Antarctica and because offshore oil operators have designed successful systems to operate under conditions suggested by many of the other factors. Ice is a significant design factor for any offshore system because the structural loads imposed by moving ice can be huge. Moving glaciers will not be resisted by any normal structure—nor will very large icebergs. The larger of the icebergs can also scour deep trenches in the seafloor (as deep as 1,500 feet in some *reports)* and thus *even* determine the depth to which pipelines must be buried.[2] In the last 10 years two ships have been sunk by ice in the Ross Sea.

The glacier ice that covers almost all of the Antarctic continent with an average thickness of almost 2 miles also extends offshore in many areas. The Ross Ice Shelf is more than 200,000 square miles in size. OTA's hypothetical oil field is located in water seaward of the northern edge of this shelf. Huge icebergs continually break off and are discharged into the ocean from the many ice shelves around the Antarctic coast.[3]

Box A-1—Antarctic Environmental Information Needs To Design Major Offshore Oil Production Systems

Ocean Environment	Knowledge of wind, waves, ocean currents, and seafloor conditions are needed to establish design criteria.
Glacial Ice	Physical properties of glacial ice are needed to develop systems that can operate on top, through, and below the ice. This includes such properties strength, temperature, plasticity, movement, etc., which can provide a basis for establishing design criteria.
Sea Ice	Thickness, coverage, strength and other physical properties of the ice are needed to develop design criteria for fixed and moored platforms, ice breakers, and shuttle tankers.
Icebergs	Size, distribution, frequency, velocities, and scour depth of icebergs are needed to design offshore structures and pipelines.
Field Description	A general knowledge of the probable location, size, depth, and formation characteristics is needed to define the most likely drilling and production means that might be used at specific reservoir 1ocations.

Note: The above data needs are general and relate to either the possibility of development in open water or beneath the ice shelf.

SOURCE: Office of Technology Assessment, 1989.

During the winter, the Southern Ocean surrounding Antarctica freezes and more than doubles the apparent size of the continent. This sea ice is generally annual ice (i.e., it melts and refreezes each year) and has a thickness of 3 to 6 feet. Such ice probably can be transited year-round with icebreakers or icebreaking tankers or, during the summer months, with only ice-reinforced ships. Annual sea ice does not appear to be a formidable problem, but more research is needed before reliable,

1A few icebergs arc of enormous size—one recently released in the Ross Sea was about twice the size of the State of Rhode Island.

2Deep Oil Technology, Inc., *Technology and Cost for Offshore Oil Development in Antarctica*, OTA contractor report, November 1988.

3L.F. Ivanhoe, "Antarctica—Operating Conditions and Petroleum prospects,' *Oil and Gas Journal, vol.* 78, No, 52, Dec. 29, 1980, pp. 212-220, year-round ice transit systems could be designed. For example, some are concerned that if regular daily transits are made by icebreaking tankers, large mounds of ice rubble could build up and restrict normal passages.

Icebergs, on the other hand, appear to be formidable in some regions.[4] Antarctic icebergs can be very large (several square miles is not unusual) and thick. It would be impossible in some cases to design structures to withstand their impact forces. However, there may be some offshore regions where large icebergs are infrequent or where they can be tracked and predicted. It is not known whether iceberg-free regions would correspond to the location of a commercial oil field. Since there is such a vast territory to explore in Antarctica, it would make sense to initiate exploration efforts in those regions where production would be most feasible. However, until more research on iceberg occurrence is done, it will not be possible to design a specific oil production system for any region in Antarctica.

Other severe environmental factors include stormy seas, extreme wind chill factors, and very low temperatures. The greater depth of Antarctica's continental shelf (e.g., the seaward edge of the geologically interesting Ross Sea shelf[5] lies in about 2,600 feet of water) adds to the technical complexity of offshore drilling and production. In combination with severe storms and problems related to ice (such as quick moving pack ice and tabular icebergs that have been observed grounded at depths of more than 1,600 fee@), the difficulty of exploring for and producing oil in some regions of Antarctica could be formidable even compared to nearshore Arctic waters.

In general, the rigorous environment of Antarctica is such that oil and gas production there (if, indeed, exploitable quantities are discovered) is likely to be more difficult than existing production anywhere else in the world. Some of the biggest challenges to date for the oil industry have been exploration for oil and gas resources in the Canadian Arctic and in the Beaufort and Bering Seas offshore Alaska. Antarctica is colder, more stormy, and more isolated than these areas, and has a continental shelf three to six times deeper than the global mean.[7] But it is the iceberg problem that sets Antarctica apart from most Arctic offshore regions. Each of these environmental constraints adds to the difficulty of exploring for and producing oil in Antarctica.

For a future Antarctic development, structures could be designed and built to withstand the cold temperatures and to protect people from the worst effects of extreme cold; however, careful designs would be required to keep equipment running smoothly and people working efficiently. Offshore structures and ships would need to be built to withstand hazards caused by a variety of ice forms. These hazards include moving sea ice, pressure ridges, icebergs, ice buildup on platforms and ships, permafrost, and ice scour of the seabed. Innovative engineering solutions to some Arctic problems could be a useful guide. However, in areas such as the Beaufort Sea where ice conditions are severe, industry has not yet discovered fields that require production systems very far offshore, into very deep water, or into the dynamic multiyear ice zone. If such Arctic development does advance in the future, it could offer useful engineering lessons for Antarctica.

Antarctica is one of the most isolated places on Earth. The Ross Sea in Antarctica is about 2,000 miles from New Zealand. In contrast the remote Navarin Basin in the Bering Sea off Alaska is about 600 miles from a potential support base and itself poses extreme logistics problems that would significantly affect the economics of oil exploration and production there. Oil may be produced (if discovered) in the Bering Sea but even here a large amount would have to be recoverable to make operations profitable. One characteristic of frontier areas like the Navarin Basin and any area in Antarctica is that there is little or no existing infrastructure. The only existing infrasturcture in Antarctica supports the scientific program. This means that everything-men, equipment, supplies, housing, entertainment, etc.—must be brought from someplace else, and at considerable expense. Conversely, produced oil must be transported long distances to markets. Moreover, the currently feasible options for transporting Antarctic oil (e.g., icebreaking tankers) will be expensive and will require some technological development. It is worth noting that Alaska's North Slope oil is transported overland by an 800-mile pipeline to an ice-free port to avoid the need for icebreaking tankers.

An additional constraint in Antarctica is that about 98 percent of the land is buried beneath a thick continental ice sheet. Not only does this preclude oil drilling with today's technology on all but the 2 percent of Antarctica not covered by ice, but very few sites are available on which advance support bases for offshore exploration could be located. Ice-free areas may also be sites of penguin rookeries, and an oil company that wished to

[4]H. Keys, "Icebergs Off South Victoria Land, Antarctica," *New Zealand Antarctic Record,* vol. *6, No.* 2, 1985, pp. 1-7.

[5]J.C. Behrendt (ed.), "Are There Petroleum Resources in Antarctica," *Petroleum and Mineral Resources of Antarctica,* U.S. Geological Survey Circular 909, 1983, p. 22.

[6]Central Intelligence Agency, *Polar Regions Atlas,* 1978, p. 38.

[7]Ibid., p. 35.

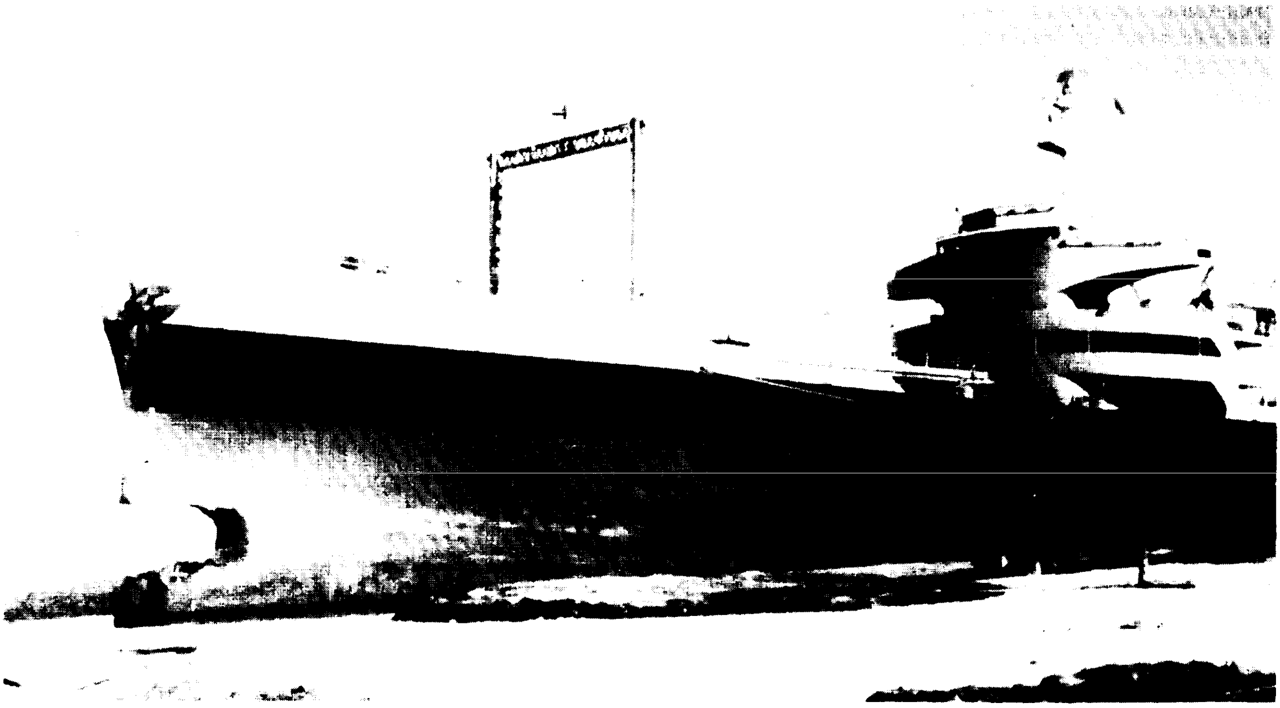


Photo credit: Bill Westermeyer

The Maumee, the oil tanker that resupplies McMurdo, after it hit an iceberg in 1976. The iceberg put a 35-foot gash in the tanker's bow, but no oil was spilled.

locate a support base at such a site could expect strong opposition from environmental groups. Moreover, there is no guarantee that a suitable location for a support base will be found near an offshore oil prospect.

Even so, a supergiant oil field of high-grade producibility could be a powerful incentive for industry to invest in Antarctica. The offshore petroleum industry is now working in some harsh environments that also pose large challenges to design engineers. Major exploration activities are currently underway in a number of hostile regions, such as in the severe ice conditions of the Beaufort and Chukchi Seas offshore Alaska and Canada, in iceberg areas along Greenland and eastern Canada, and in the North Sea, North Atlantic, and Norwegian Sea. The most significant oil production experience in harsh environments to date is in the North Sea, but very deep water production (2,000 feet) has begun in such areas as the Gulf of Mexico and offshore Brazil; and, in a few years, production will probably commence from fields offshore Labrador.

In addition, recent leases were sold and plans are underway to drill exploratory wells in the Chukchi Sea north of Alaska, where thick, moving, multiyear sea ice is prevalent. Some of these ice conditions maybe even more severe than those in Antarctica, even though the depth of water in the Chukchi Sea seldom exceeds 150 feet. Other companies are accomplishing exploration drilling in the North Atlantic west of the Shetland Islands in regions of deep water and very rough seas. Still other companies are planning exploration in areas of the Gulf of Mexico and elsewhere where water depths are as great as 10,000 feet.[8] One company is proceeding with development of an oil field just 500 miles north of the Antarctic Peninsula, off Argentina's Tierra del Fuego.[9] Another has begun engineering on the production facilities for the Hibemia oil field in "Iceberg Alley' on the Grand Banks of Newfoundland.[10] Harsh environments requiring unique and costly

[8] Keys, op. cit., footnote 4.

[9] "First Offshore Argentine Oil Being Developed by Total,'" *Ocean Industry*, vol. 23, No. 9, September 1988, pp. 115-116.

[10] "Mobil Names Firms Eligible To Bid on Hibernia Project,' *Oil and Gas Journal*, vol. 86, No. 52, Dec. 26, 1988, p. 28.

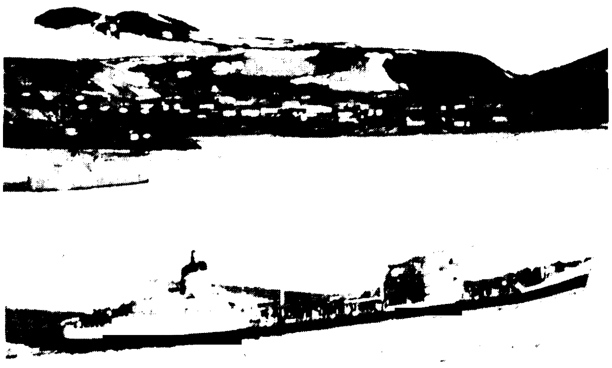


Photo credit: Ann Hawthorne

The Maumeenear McMurdo in 1988 escorted by the Coast Guard icebreaker, ***Polar Star.*** If oil is ever developed in Antarctica, ice-strengthened or, more likely, icebreaking, tankers will be needed.

technical approaches have not deterred petroleum exploration and development ventures.

OFFSHORE TECHNOLOGIES FOR HARSH POLAR ENVIRONMENTS

Current offshore oil and gas operations and planned systems for harsh environments around the world form the basis of any projections of technologies that may be used in future Antarctic petroleum development. Technologies employed by the offshore petroleum industry have changed dramatically over the past 20 years allowing exploration and production in environments that were considered almost prohibitive two decades ago. These technology changes can be expected to continue, but the nature and extent of advances three to five decades in the future are hard to predict, Industry has moved into hostile environments in discrete incremental steps, progressively resolving the problems encountered, adapting existing systems or techniques, and designing new ones as needed. That technology base today is available for adaptation to Antarctica by the major, experienced operators in the same manner-in discrete, incremental Steps.[11]

Offshore petroleum activities are commonly divided into three phases: exploration, development, and production. Exploration includes geological and geophysical surveys as well as exploratory drilling. In the Mineral Convention's terms, this includes both "prospecting" and ''exploration. Development begins after an oil discovery is determined to be economic and includes drilling of production wells and the design and construction of all platforms and facilities for producing the field. Production begins with the flow of oil to the market and continues until the field is depleted. In offshore hostile regions, exploration has taken on the order of 10 years or more, development work has taken about 10 years, and production continues for 20 years or more. After initial operations commence, some of these phases can be accomplished concurrently.

Adequate exploration technology (both geophysical survey ships and mobile exploratory drilling vessels) is available today to work in many of the offshore Antarctic regions, In fact, some seismic surveys have already been done by the U.S. Geological Survey and several nations working in Antarctica. Also, U.S.-based geophysical survey firms have proposed, to a number of oil companies, to conduct further seismic operations in Antarctica. These operations are conducted during the summer months in ice-free waters. Scientific drilling operations have also taken place at a number of sites surrounding Antarctica the most notable of which were under the auspices of the Deep Sea Drilling Program in the 1970s. These and other scientific drilling operations were conducted during the summer months in ice-free waters. None of this scientific drilling was to adequate depth or at the proper locations to be considered part of an oil exploration program.

A number of mobile drilling platforms operating in the world today have the capability of drilling exploration wells offshore Antarctica (such as in the Ross Sea) during the summer months and in up to 50 percent ice coverage. The most suitable drilling rig would probably be a heavy-duty semi-submersible exploratory drilling vessel similar to that used in the North Atlantic or the Bering Sea offshore Alaska. Exploratory drilling could be accomplished over a number of summer seasons, much as is done off Alaska and no major extension of existing technology would be needed.

The present technology for production systems will have to be developed further to make offshore Antarctic oil production feasible. Systems are currently available in areas of minimum ice encroachment. Where ice is present, parts of deepwater systems would have to be combined with systems designed for Arctic conditions. Such combinations could include floating terminals and/or subsea wells like those used in the North Sea; tanker shuttle operations like those used in the Labrador Sea; and ice-reinforced structures like those used in the Cook Inlet.

[11] U S. Congress, Office of Technology Assessment, *Oil and* Gas *Technologies for the Arctic and Deepwater*, OTA-O-270 (Washington, DC: U.S. Congress, Office of Technology Assessment, May 1985).

Ongoing industry R&D programs could develop additional components needed for Antarctic production. For example, considerable research is underway on remote control systems for subsea wells. Two-phase pumping systems are also being developed so that produced gas and oil can be moved long distances before it is necessary to provide a large separation facility. It is reasonable to assume that many of these technologies will advance in the next few decades and be available for any oil production allowed in Antarctica.

A HYPOTHETICAL SCENARIO FOR ANTARCTIC DEVELOPMENT

Technology Assumptions

OTA's hypothetical scenario contains a number of technology assumptions. It assumes that technology for operating in ice-covered continental shelves will advance on all fronts. This could bring the cost of oil extracted from frontier areas down, closer to the cost of today's cheaper oil. For example, oil is profitably produced in Prudhoe Bay on the North Slope of Alaska, moved to Valdez by pipeline, shipped to the Panama Canal by tanker, moved by pipeline across the Canal, and shipped by tanker to the Gulf of Mexico. It seems reasonable that 30 years hence, technology will be readily available to ship oil from offshore Antarctica to New Zealand or Argentina by ice-strengthened or icebreaking tankers and then to any location in the world in conventional tankers.

Developments in technology could also affect OTA's assumptions about Antarctic exploration and develop ment. For example, 30 years hence, improved geophysical techniques could significantly decrease the cost of finding oil. This could result in lower delineation drilling costs, because fewer wells will be needed to find and delineate fields. Improved drilling techniques such as use of down-hole motors and surface control and monitoring, could lower drilling costs as well. Improvements in production techniques such as use of multiphase pumps, flexible pipelines, compliant platforms, ice-strengthened platforms, etc., all tend to reduce the relative cost of harsh environment field developments. Transportation technology could also reduce costs through use of improved ice-operating tankers, deep-water pipeline systems, better loading techniques, etc. Box A-2 summarizes key technological advancements beyond current technology that OTA concludes are needed for developing an Antarctic oilfield.

If the above technical developments occur, there would seem to be no insurmountable technical barriers to oil exploration and development of Antarctica's offshore sedimentary basins. The relative technical difficulty in developing oil in Antarctica today is probably less than it was for developing fields in the Beaufort Sea 30 years ago. other fields (e.g., in the Chukchi Sea) will probably be developed and be operating over the next 30 years, advancing the technology needed for Antarctica.

Box A-2-Summary of Key Technology Advancements Needed To Design Antarctic Offshore Oil Production Systems

- High-capacity mooring systems to keep floating drilling and production platforms on location during heavy ice coverage.
- Seafloor storage tanks for holding oil on the seafloor in iceberg-infested waters.
- Long-range subsea control systems that will allow wells to be located long distances from production facilities.
- Two-phase flow pumps that will allow oil and gas to be transferred long distances without separation.
- Remote operated vehicles that will provide a means of installing and servicing seafloor equipment in deep water and Mow the ice shelf.
- Mini-submarin es or remotely operated vehicles that can provide direct access to seafloor equipment.
- Icebreaking tankers for transporting oil year round from Antarctica to an ice-free transfer terminal.
- Flexible pipelines that can accommodate relative movement between the seafloor and a floating platform.
- A means for keeping an access hole open through glacier ice to allow wellheads to be located on the seafloor or ground.

SOURCE: Office of Technology Assessment, 1989.

An Oil Consortium for Antarctica

Major international oil companies, in partnership with each other and/or with state oil enterprises, would be the likely "Operators" of any Antarctic oil exploration and development if the Minerals Convention enters into force.[12]

A consortium of major oil companies and national oil companies would be the most likely organizational approach because of the finances that will be required and because individual companies probably will be averse to "going it alone." Most major, high-risk oil development ventures, such as those in Arctic and deepwater offshore areas, are undertaken by such consortia.

[12] J.N. Garrett, *The Antarctic Minerals Regime: A Petroleum Industry Perspective*, OTA contractor report, November 1988.

For the purposes of this scenario, OTA has assumed that:

- The consortium chooses the United States to be its sponsor.
- Seismic prospecting in the Ross Sea identifies factors that suggest significant oil accumulations.
- The same area also would be recognized as highly prospective by other operators and that there would be competing applications for the area of interest.
- Subsequent to receiving an exploration permit for the desired blocks, a wildcat well and follow-up delineation wells indicated the existence of an oil field containing 4 billion barrels of recoverable oil with very good reservoir and producing characteristics.
- The field ultimately was developed to a peak producing capacity of 700,000 barrels per day of crude oil.

OTA chose the Ross Sea as a possible location for a hypothetical oil field development because some evidence points to favorable conditions for oil accumulation in the sedimentary rocks there and because reconnaissance seismic surveys have been conducted in some of the prospective basins there. Based on preliminary evidence, a number of geologists believe the Ross Sea to have the best basins for petroleum formation of any of the Antarctic prospects identified to date (see ch. 4).

The hypothetical consortium is assumed to be the operating unit of the oil venture and to consist of four major international oil companies headquartered in the United States, The joint operation would cover activities ranging from prospecting through exploration and development stages to the construction of a transportation system. Consortium members each would provide managerial, professional, technical, and support personnel required to staff the Antarctic operation,

If convinced that an initial investment in an Antarctic venture could be justified, the consortium would appreach the appropriate agency of the U.S. Government about prospecting (i.e., in the Ross Sea using seismic survey techniques). Subsequent to supplying the appropriate agency with the information prescribed in Article 3713 of the Minerals Convention, the United States, as the Sponsoring State, would notice the Commission of the proposed prospecting plan. If the Commission did not raise any objections, the survey would be conducted. The details pertaining to a hypothetical reconnaissance seismic survey are shown in box A-3.

Assuming the results of the reconnaissance seismic work indicated favorable areas, the most prospective sector would be selected. The consortium would then request its Sponsoring State to ask the Commission to have the subject area identified for possible exploration and development activities.

If the area identification request is approved, the consortium would tender an application for an exploration permit through its sponsor, to the Regulatory Committee formed for the area. At this point the consortium could also include a participation agreement with state oil companies of several developing countries. Such an approach may be desirable, given that a decision on an application is to be based on a measure of wide participation-especially if the area is of interest to a number of competitors.

Under the terms of the Convention, the Regulatory Committee will divide a given area into a grid pattern of ‘‘blocks, ’ that is, leasable tracts, and accept applications for permits for Operators to work within those blocks. The Committee would also put limits on the number of blocks that would be allocated to any Operator and then resolve competing applications for the same blocks. The method of resolving competition for the same blocks is not spelled out in the Convention but would be for the Regulatory Committees to work out. (The “bonus bid” method common to offshore lease sales in the United States could be one option.)

Since the convention does not specify a method for establishing the blocks, OTA has developed a method that appears to be practical and within the intent of the Convention terms. That method is described in box A-4.

A Hypothetical Exploration Program

Once blocks have been established and allocated, exploration commences. Reconnaissance seismic surveys indicate the areas of interest and reveal the most promising. For the purposes of this example, OTA assumes the most promising area to be the Terror Rift of the Victoria Land Basin. This region has been identified in a number of studies as having potential for hydrocarbon accumulation. *4 Assuming the consortium is awarded an exploration permit by the Regulatory Committee for three blocks of 3,600 square miles each (see figure A-2), it would then conduct a more detailed seismic survey of the three-block area.

[13]Such information includes identification of the area, the resources subject to prospecting, the prospecting methods and work program, and the monitoring and prevention practices; an assessment of environmental impacts; and organizational and financial qualifications.

[14]For example, see A.K. Cooper, F.I. Davey, and K. Hinz, ‘‘Rms Sea—Geology, Hydrocarbon Potential,'' *Oil and* Gas *Journal*, vol. 86, No. 45, Nov. 7, 1988, pp. 54-58.

Box A-3—A Hypothetical Reconnaissance Seismic Survey

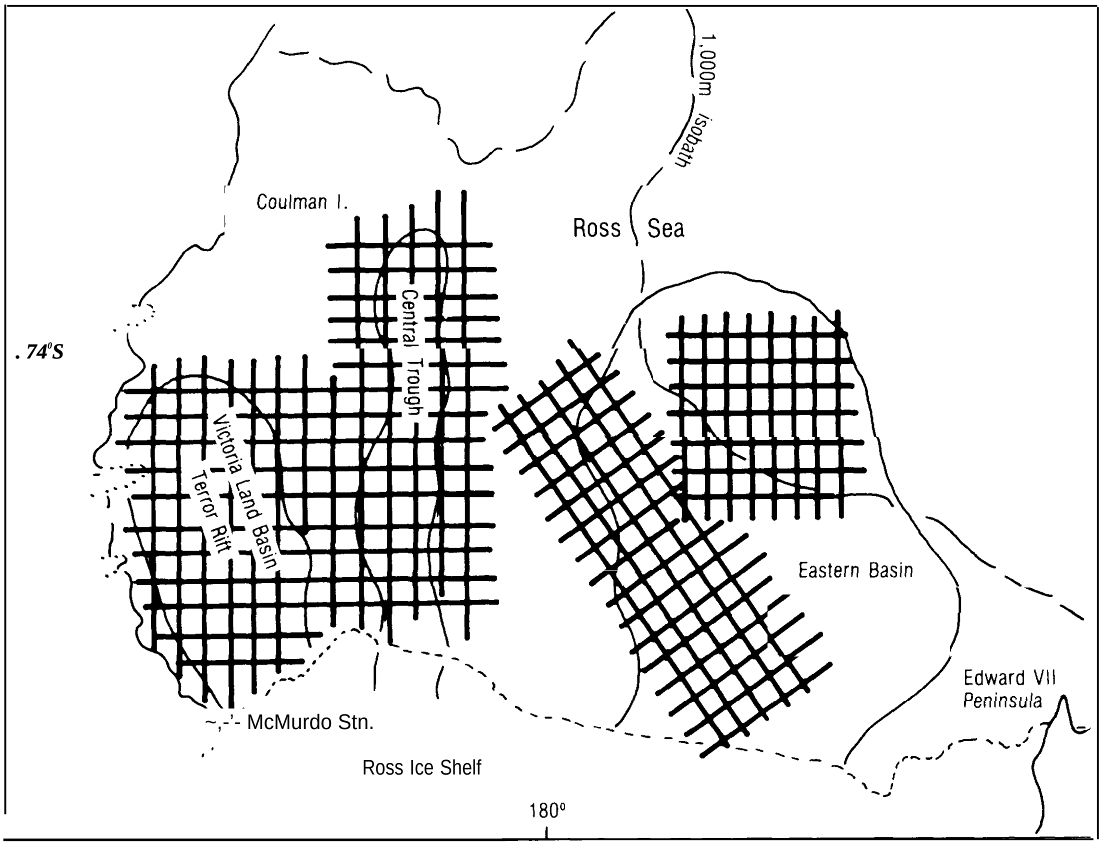
Within the Ross Sea, three prospective structural basins are indicated that warrant investigation by seismic methods. These basins and some of their physical characteristics are:

Basin	Basinal area with sediments >16,000' thick in square nautical miles	Maximum indicated thickness thickness of sediments in feet	Nautical Miles Seismic Line
Victoria Land Basin	8,650 nm^2	46,000 (14,000 meters)	1,400
Central Trough	2,500 nm^2	20,000 (6,000 meters)	1,500
Eastern Basin	11,000 nm^2	20,000 (6,000 meters)	2,700
			Total = 5,600

Reconnaissance seismic surveying is conducted over the entirety of the Victoria Land Basin and the Central Trough. However, in the Eastern Basin (45,000 square nautical miles total area) much of the basin has a comparatively thin sedimentary cover; accordingly, only the deeper, potentially oil-bearing portions of the basin are investigated. All seismic surveying is carried out in open water. The lines are shot over a 20-nautical-mile grid. A map showing the approximate positions of the seismic lines is attached (figure A-l).

SOURCE: Office of Technology Assessment, 1989.

Figure A-l—The Ross Sea, Antarctica: Reconnaissance Seismic Survey Lines



The reconnaissance lines will be shot over a 20 nautical-mile grid across indicated structural basins

Seismic lines

Basin	Reconnaissance seismic line males
Victoria Land Basin	1,400 nm
Central Trough	1,500 nm
Eastern Basin	2,700 nm
Total	5,600 nm

SOURCE: J.N. Garrett, "The Antarctic Minerals Regime: A Petroleum Industry Perspective," OTA contractor report, January 1989, Adapted from D.H. Elliot, "Antarctica: Is There Any 011 and Natural Gas?" Oceanus, vol. 31, No. 2, Summer 1988, p. 35.

Box A-4-A Possible Approach To Delimiting Blocks for Petroleum Operations in Antarctic Walers

The Convention on the Regulation of Antarctic Mineral Resource Activities does not specify the size of, or the methods of determining, the blocks within which mineral extractive activities may be undertaken in Antarctica. Block size and designation in the Convention are not specified. Reference to such blocks is made in Article 43 only to the extent that the Antarctic Mineral Resources Commission will ''adopt measures with respect to maximum block sizes' and that the relevant Regulatory Committee will ''make provision for a limit in appropriate circumstances on the number of blocks to be accorded to any party. "

A practical approach to the delimitation of blocks pertinent to offshore petroleum operations is suggested here. The blocks would be vastly larger than those associated with the Gulf of Mexico or North Sea tracts because they must be large enough to facilitate operational flexibility and maximize the chances of discovery of billion-barrel plus oil fields. If the blocks are not very large, the petroleum industry would be unwilling to undertake Antarctic operations.

'The plan subdivides areas into blocks, each of which is 60 nautical miles on a side (i.e., each block side corresponds to one degree of longitude as measured at the equator). The dimensions of each block are:

Unit	Area
Square nautical miles	3,600
Square statute miles	4,774
Square kilometers	12,364
Acres	3,055,259
Hectares	1,236,430

The blocks apply, in this example, to the Ross Sea; wherever a block crosses a land/sea interface, only the seaward block portion constitutes explodable/exploitable acreage. The block grid system begins immediately north of the Ross Ice Shelf. The block mumbering system starts in the southwest, near McMurdo Station, with Blocks 1A, IB, IC . . . progressing eastward; block grid numbers increase progressively northward. See map in figure A-2.

SOURCE: Office of Technology Assessment, 1989.

If results of the detailed seismic work indicate the presence of many structural features, several would be drilled and tested, These are known as wildcat wells. OTA assumes the first four wildcat wells are either dry or did not penetrate a commercial discovery but that the fifth well indicates a significant oil discovery. This is a generally optimistic assumption for exploration success in a new frontier area, but it could be realistic if substantial y more scientific assessment of resource potential is accomplished.

Following intensive testing of the initial discovery well, OTA assumes that 11 additional wells are drilled to ascertain the extent of the discovery, the vertical height of the oil column, and whether or not a primary gas cap is present. Table A-1 illustrates the assumed field characteristics of this discovery.

The assumptions made here about wildcat well numbers, the extent of delineation drilling, and the size and characteristics of the oil field are very optimistic, and represent a "best case' scenario. It is not necessarily the most likely scenario, but it illustrates what a development might look like, what technologies are needed, what it might cost, and how long it would take to develop, By making favorable assumptions, OTA has established a baseline scenario that could be modified with a number of less favorable assumptions.

A Hypothetical Development Program

OTA assumes that, on the completion of delineation wells, the consortium, through the sponsoring state, would apply to the Regulatory Committee for a develop ment permit. This application would be accompanied by an updated and more detailed description of the develop ment plan, including the well spacing scheme, platform and gathering facility design, drilling and platform installation schedule, and the estimated field production profile. It would detail the transportation methods and would include a detailed, updated environmental impact statement for the planned development. The Sponsor would recertify the technical competence and the finan-

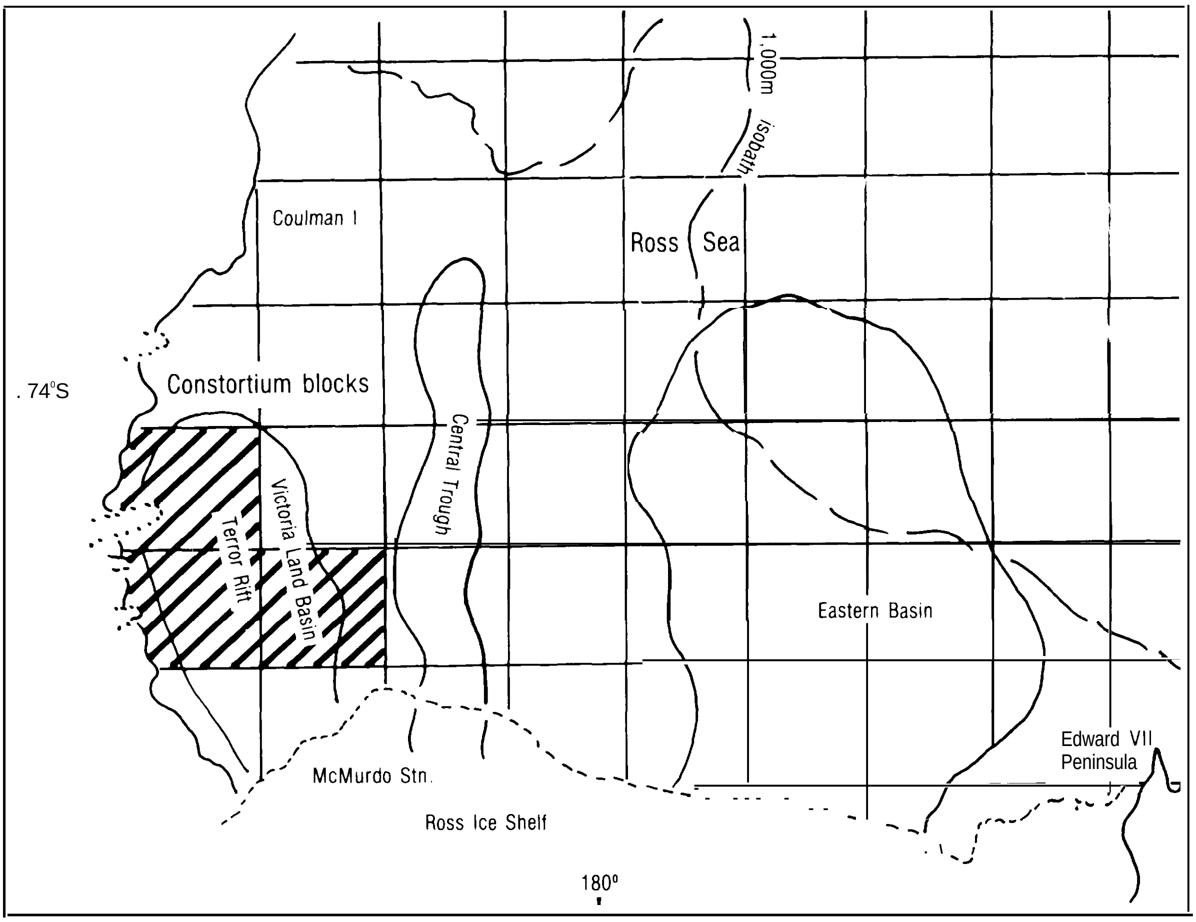
Table A-1-Characteristics of Hypothetical Discovery

Field classification	Field area	Average net oil	Recoverable oil reserves
Super-giant field	31,500 acres	200 feet	4 billion bbls.

NOTE: In the assumed discovery, no primary gas cap is penetrated, the oil pool is determined to be undersaturated and the reservoir drive mechanism is a partial water drive in conjunction with solution gas expansion.

SOURCE: Office of Technology Assessment, 1989

Figure A-2—A Hypothetical Plan for Dellmiting Blocks Dedicated to Offshore Petroleum Operation



Each square block measures 60 nautical miles on each side (i. e., each block side corresponds to one degree of longitude at the equator)

Area dimensions of each block

Unit	Acres
Square nautical miles	3.600
Acres	3,055,255

SOURCE: J.N. Garrett, "The Antarctic Minerals Regime: A Petroleum Industry Perspective," OTA contractor report, January 1989. Adapted from D.H. Elliot, "Antarctica: Is There Any Oil and Natural Gas?" ***Oceanus,*** vol. 31, No. 2, Summer 1988, p. 35.

cial capability of the consortium to carry out the updated development plan.

If the Regulatory Committee approved the updated development plan,[15] a development permit would be issued. (Note that the development plan that was submitted as part of the original application for the exploration permit would have been more general because the size and producing characteristics of the anticipated oil field discovery would have been unclear when the initial plan was drawn up,)

In the OTA scenario, the approved development plan provides for drilling 258 producing wells and 48 water injectors from 6 production platforms. Peak production capacity is 700,000 barrels of oil per day, and the expected field life is in excess of 30 years, during which approximately 4 billion barrels of oil would be produced (see box A-5).

[15] See ch. 3 about more detail regarding modifications to development plans.

Box A-5—Summary of Physical and Technical Aspects of the Hypothetical Oil Field

The Oil Field

- Field dimensions: 10 miles long x 5 miles wide
- Reservoir depth: 8,900 feet to 9,300 feet subsea
- Average net oil sand thickness: 200 feet
- Crude oil gravity: 32 degrees American Petroleum Institute
- Crude oil type: sweet
- Water depth: 2,500 feet

Recoverable Oil Reserves

- Reservoir volume: 6,300,000 acre feet
- Oil initially in place: 10 billion barrels
- Recoverable oil reserves: 4 billion barrels

Producing Characteristics

- ***Type of*** platform: floating drilling/production/storage vessel; high-capacity mooring system; subsea wells with production risers to floating vessel
- Well spacing = 120 acres/well
- Total of 258 wells to drain the 31,500-acre field.
- Six platforms: 43 production wells and 8 water injection wells each.
- Maximum producing rate: 700,000 barrels per day
- First production platform yield 125,000 barrels per day for 8 years.

Transportation

- Icebreaking shuttle tankers to ice-flee terminal

Support

- All facilities on platform
- Crew/resupply with shuttle tankers

Development Schedule

- Commercial exploration: 2,000-2,010
- Initial discovery: 2,010-2,020
- Develop initial field: 2,020-2,030
- Start production: 2,030-2,040

Note: The production rate for this hypothetical field is low compared with other world class fields. A high production rate would improve the resulting economics.

SOURCE: Office of Technology Assessment, 1989.

Hypothetical Development Technologies

Three basic development systems could be used in this scenario. The actual system used would depend mainly on the prevailing ice conditions at the field site. System A would be used if the field were located where only sea ice is present and large icebergs are rare. System B would be used in an area where large icebergs were more frequent, thus requiring disconnection of the surface platform from the wellheads. System C would be used on an ice shelf or on the ice capon land. In general, then, *'A' would be an appropriate system farthest out to sea (or where icebergs are a rare occurrence), "B" closer to the shoreline (or where large icebergs are more frequent), and "C' on permanent ice. The following briefly describes the features of the three possible systems.

System A

This would incorporate large floating systems and be used in deep water where very large icebergs were extremely rare. It would have disconnect features that would allow it to be located in areas where icebergs might be unusual. Further, such systems could be designed to withstand icebergs as large as 1 mile square and 300 feet thick. A number of such systems have been tested or proposed.[16,17,18,19] One is shown in figure A-3.

System B

This approach incorporates substantial subsea systems, including seafloor well heads with advanced control systems and two phase pumps that allow oil to be transferred long distances. The production and storage system would be located remotely in a floating vessel, on the seafloor, or on land. Figure A-4 shows a floating vessel with emergency disconnect features.

Seafloor oil storage systems would allow fields to be developed in regions where icebergs are abundant and would make unnecessary the use of permanent surface facilities above well heads, From storage, oil could be transferred to surface facilities located up to several hundred miles away in an iceberg-tie area. Access to well heads could be achieved during ice-free months from the surface above. Recent industry designs, proposals, and R&D on components needed to develop this system

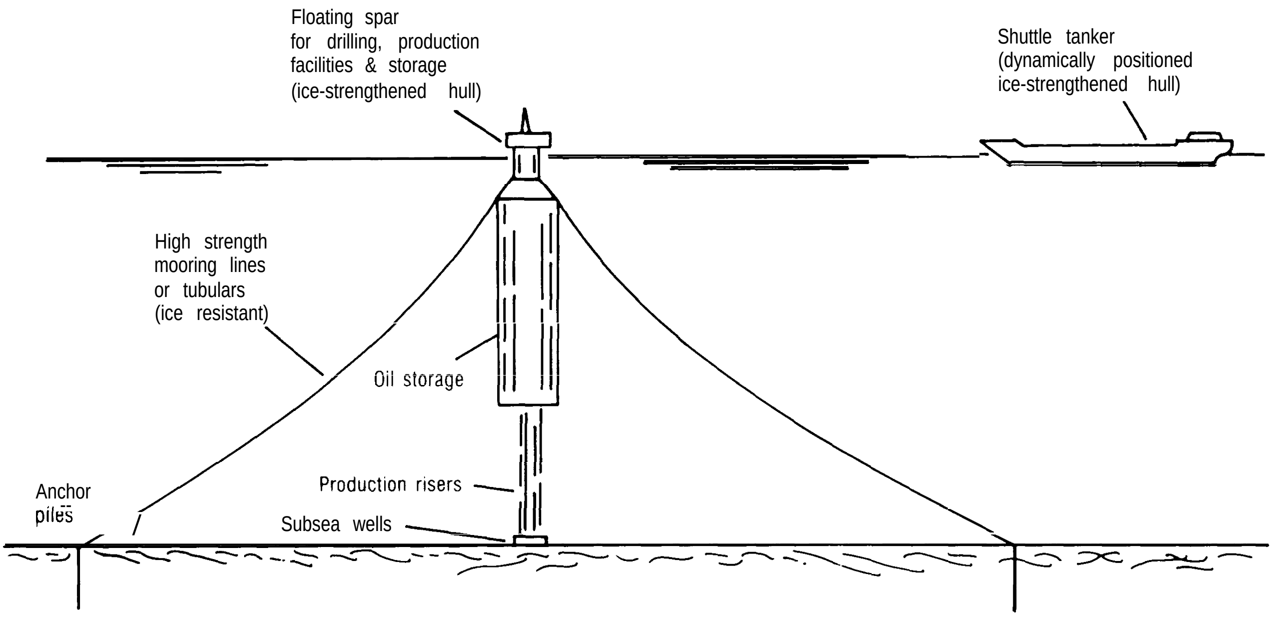
[16] G.D. Watson, S.P. Koch, and J.J. Every, 'Model Testing of a Deepwater SALM/Tanker System,'' *British Maritime Technology,* Offshore Technology Conference paper 5672, 1988, p. 505.

[17] R. Wilson, Cameron Iron Works Ltd., ''A Review of the Development of the SWOPS Subsea Production System,'' Offshore Technology Conference paper 5724, 1988, p. 373.

[18] J.E. Halkyard and T.L. Johnson, Arctec Offshore Corp; S. Hanna, Placid Oil co.; and L.C. Kwok, Arctec Offshore Corp; "A Summary of a Multi-Faceted Physical Model Test Program of a Floating Drilling and Production System,'' Offshore Technology Conference paper 5674, 1988, p. 523.

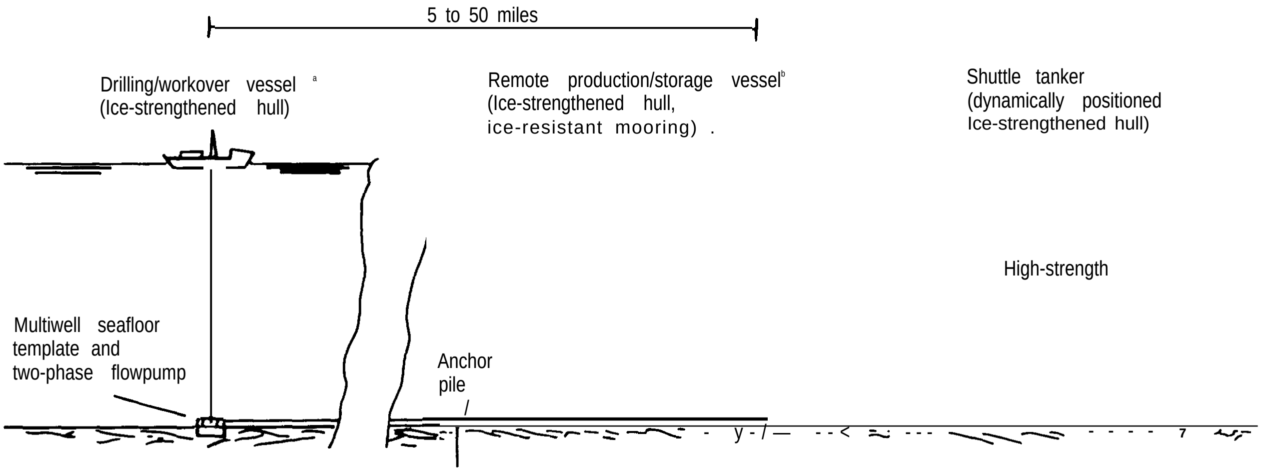
[19] R.J. Allan, Reading and Bates Drilling Co., "Integratd Motion, Stability, and Variable Load Design of the Trendsetter Class Semisubmersible Zane Barnes,'' Offshore Technology Conference paper 5625, 1988, p. 87.

Figure A-3-Antarctica Development System "A" (Iceberg-Free Region)



SOURCE: Deep Oil Technology, Inc., "Technology and Coet for Offshore Oil Development in Antarctica," OTA contractor report, November 1988.

Figure A-4-Antarctica Development System "B" (Iceberg Region)



[a] Vessel is on location only during drilling operations

[b] Other storage options Include seafloor storage or land storage

SOURCE: Deep Oil Technology, Inc., "Technology and Cost for Offshore Oil Development in Antarctica," OTA contractor report, November 1988.

provide a basis for projecting the availability of this technology.[20,21,22,23,24,25,26,27,28] If gas/oil mixtures could be pumped long distances and production complexes could operate effectively on the seafloor, a total production system could be built. The general problem of moving oil/gas mixtures long distances before processing is one the industry has been working on for a long time.

System C

From the ice shelf or on glacier ice covering the land mass (figure A-5), oil could be extracted through an open hole filled with heated water or another nonfreezing liquid. The well head would be located on the seafloor (or land) and connect by risers to the surface facility. The concept presumes that, where the ice is moving, the hole could be advanced by continuously melting the ice surrounding the risers to keep the surface facility positioned over the wellhead. The concept would use an approach similar to deepwater floating production platforms that are operating in many locations today.

System A would use mostly existing technology; system B would use existing technology and that currently under development. Its key components (subSea wells, multiphase pumps, seafloor separators, and reliable control systems and disconnect features) would be in use elsewhere before the year ***2020.*** System C is the most speculative, but appears feasible and could be investigated more closely once the characteristics of thick ice are better understood. Some R&D on this technology has already been done.[29]

The transportation portion of each of the above systems probably requires only a modification of existing technology or past designs.[30,31] Oil could be moved by tanker from Antarctica to ice-free land locations for shipment to markets in the Northern Hemisphere, Distances to ice-tie

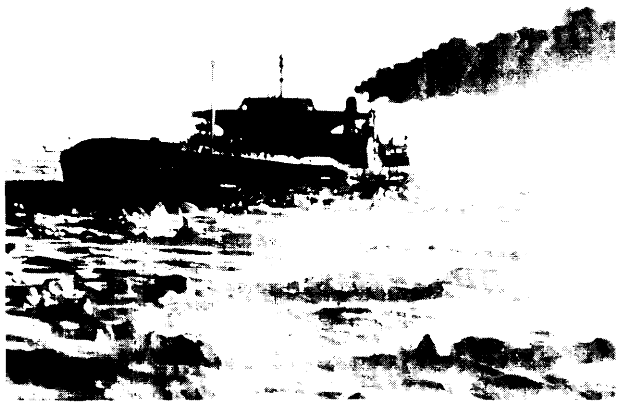


Photo Credit: ***Exxon***

In 1969 the S.S. Manhatten tested the feasibility of transporting oil by ice-strengthened tanker through the Northwest Passage.

locations could range from 1,000 to ***2,000*** miles. Special icebreaking or ice-strengthened tankers and icebreakers would be used to transport oil to transfer terminals. From here the oil could be shipped to any location in the world. Pipelines could also be used to transfer oil from various points within Antarctica to loading points only along very selective routes. Hazards such as ice scouring and permafrost would have to be taken into consideration. If the hazards appeared substantial enough, new technologies might have to be developed.

An oil field in relatively deep, iceberg-free water, using System A, appears at present the most likely type of Antarctic oil field to be developed. Subsequent development, if any, might then move closer to the shoreline where icebergs would be more of a problem. Later,

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[20] B. Darde and A. Lafaille, Total-CP; and P. Durando, Inst. Francais du Petrole, "One-Megawatt Subsea Matable Electric Connector: Key to Multiphase Pump Drive Assembly—Now Field Proven," Offshore Technology Conference paper 5647, 1988, p. 263.

[21] M.P. Arnaudeau, Inst. Francais du Petrole, "Development of a Two-phase Oil Pumping System for Evacuating Subsea Production Without Processing Over a Long Distance: Poseidon project," Offshore Technology Conference paper 5648, 1988, p. 271.

[22] H.A. Herwig and J.M. Cattanach, Ferranti Subsea Systems Ltd., "Standardization of North Sea Multiplexed Control Systems for Ilvm-Assisted Developments,' Offshore Technology Conference paper 5670, 1988, p. 489.

[23] R.J. Emptage, Cameron Iron Works Ltd., "A Review of the Satellite Production System (SPS) Ness Development," Offshore Technology Conference paper 5723, 1988, p. 367.

[24] K. Hogland, ABB-Atom Advanced Systems, and E. Nesse, Statoil A/S. "A New Approach to Subsea Intervention,' Offshore Technology Conference paper 5728, 1988, p. 407.

[25] "Offshore Production Without Platforms?" *Offshore Incorporating The Oilman*, International Edition, vol. 48, No. 12, December 1988.

[26] "Separating Separation From the Platform," *Offshore Incorporating The Oilman*, International Edition, vol. 48, No. 12, December 1988.

[27] 'Multiphase Pumps Delivered to Researc h Participants," *Offshore Incorporating the Oilman*, International Edition, vol. 48, No. 12, December 1988.

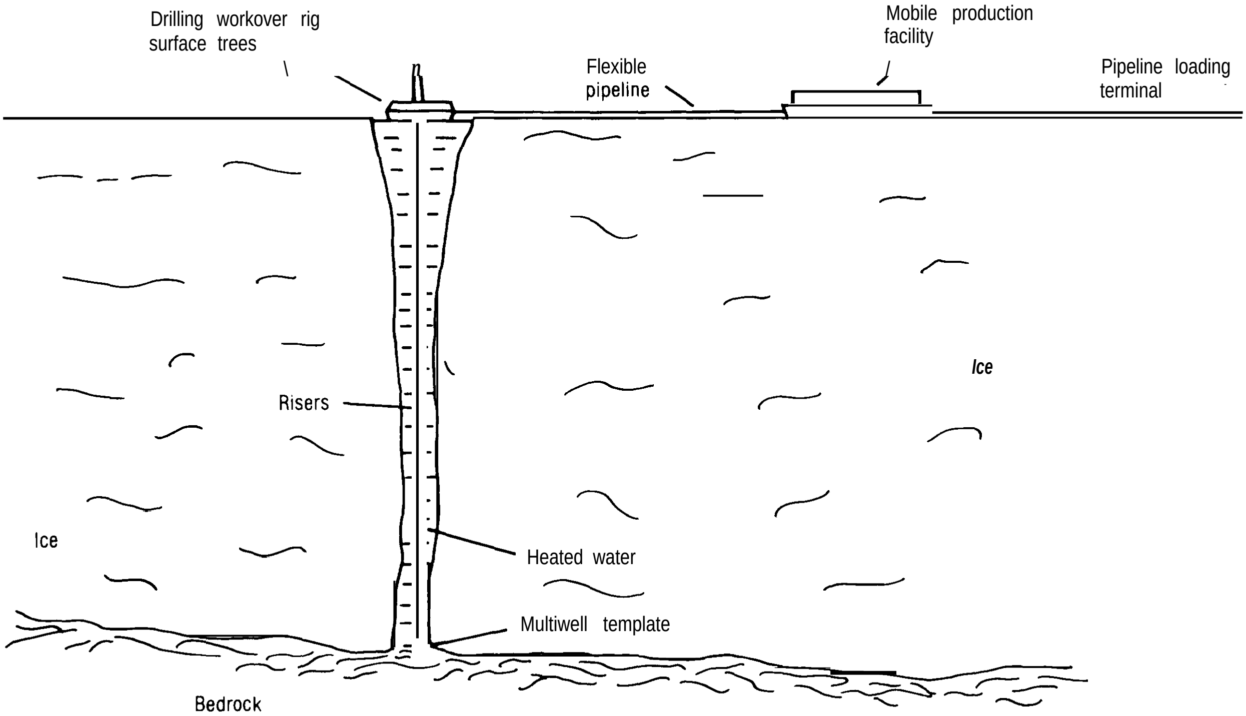
[28] K.J. Fardy, Gulf Canada Resources Ltd., and S.P. Singeetham, FMC Crop., Petroleum Equipment Group, ''Application of a Modified Subsea Wellhead System on Molikpaq, a Mobile Arctic Caisson Rig in the Canadian Beaufort Sea, Offshore Technology Conference paper 5790, 1988, p. 403.

[29] K.C. Kuivinen, Polar Ice Coring Office, University of Nebraska-Lincoln, ''Ice Drilling Technology,' paper presented at Polar Drilling Workshop, Byrd Polar Research center, The Ohio State University, Columbus, OH, Nov. 6-9, 1988.

[30] S. Gordin and D Sue-, , 'Field and Model Tests for Predicting the Icebreaking Resistance of the ARCO Arctic Tanker, ' ' Arctic Oil Technology Conference, 1985.

3114~vel_ Of an Icebreak Tanker Trartsporration System for North Slope Alaskan Gas,' ' LNG Conference, Los Angeles, CA, 1986.

Figure A-5-Antarctica Development System "C" (Ice Shelf or Ice Cap)



SURCE: Deep Oil Technology, Inc., "Technology end Cost for Offshore Oil Development in Antarctica," OTA contractor report, November 1988.

drilling on the ice shelf or ice itself could be tested. Some experts, however, argue that a system mounted on the ice shelf, System C, could be the easiest to develop; more engineering studies are needed to verify this contention.

Though OTA'S most likely scenario presumes that oil development would start from seaward locations and move toward land, costs probably would change radically as developments move landward. Since it is also much more difficult to estimate costs for a hypothetical development with technologies yet-to-be tested, OTA has prepared cost estimates only for System A.

Obviously, accurate cost estimates for development of an Antarctic oil field cannot be made at present. Nevertheless, a general look at Antarctic oil production costs cart be instructive. The assumptions and resulting figures based on the System A approach can be supported by analogy to existing operations. Expert participants in an OTA workshop on oil and gas development potential considered the following cost estimates for System A reasonable. Some even considered the following estimates too high compared to present, similar operations. Experts consider the likely costs of production using Systems B or C to be much higher, but this may not be the case if more appropriate technologies are developed in the future.

System A (figure A-3) would produce the hypothetical 4-billion-barrel field in the Ross Sea, as described. Such an operation is comparable to the recently announced plans of Mobil Oil Canada Ltd. for the Hibernia field on the Grand Banks off Newfoundland. This harsh-environment field in iceberg-filled waters is planned to be built over the next few years. A large concrete gravity structure will hold the main production facilities. Three ice-strengthened shuttle tankers will transport oil to shore.

Hypothetical Development Economics

OTA prepared a brief analysis of costs and profitability of a System A operation using the above assumptions. The estimated cost of exploration, development, and transportation is given in table A-2. The analysis estimates the profitability of oil field development under various economic scenarios that might prevail in the

Table A-2--Cost Summary for Hypothetical Development of a 4-Billion-Barrei Field-(System A) (1886 Dollars)

Expenditures	$Billions
Capital costs:	
Exploration	
(geophysics and drilling)	1.4
Development	
(platforms/wells/facilities/drilling)	22.1
Transportation	
(tankers/terminals)	4.8
Total	28.3
Cost per recoverable barrel	
(approximate capital)	$7.00
Operating costs (annual):	
Production	1.8
Transportation	0.5
Total	2.3

NOTE: The above costs include delivery of produced oil to an cc-free terminal in southern South America. *Added* transportation costs to a major refinery would be comparable to that for transport from the Persian Gulf to U.S. refineries.

SOURCE: Office of Technology Assessment, 19S9.

future. The results and findings are illustrative rather than definitive. Many unverifiable assumptions about the presence of hydrocarbons and the cost of developing them had to be made, A conventional discounted cash flow model (employing a discount rate of 10 percent) was used to measure the profitability of hypothetical projects that might arise in Antarctica. It provides for an annual accounting of exploration, development, and production activities; and all associated expenditures, production flows, revenues, and tax payments for each year of a project's life.

Each project evaluated consists of an individual oil field. Project accounting allows for several dry holes prior to the discovery of a substantial oil deposit, extends throughout the field delineation, development and production stages, and ends when annual production has fallen to the point where continued extraction is unprofitable for the Operator (the economic limit). At that point the wells are plugged and the project is abandoned. The length of the project (in years) can vary depending on the size of the hypothetical deposit and the assumed level of oil prices.

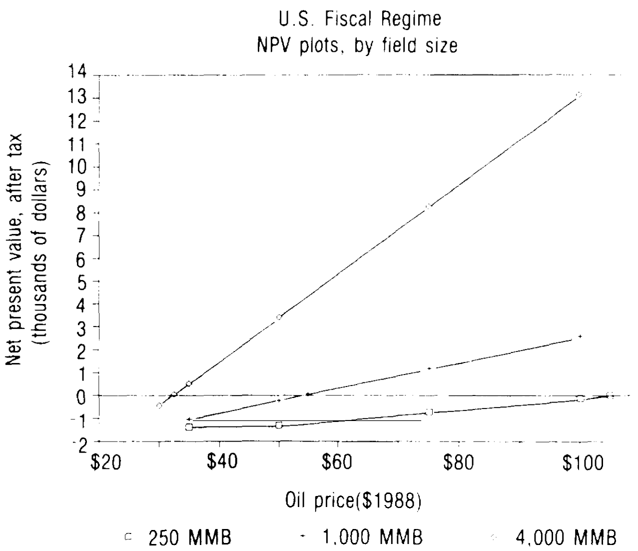
In order to evaluate the possible effect of field size on economics, three hypothetical oil deposits were evaluated, containing ***250,*** 1,000, and 4,000 million barrels of recoverable oil reserves respectively. The delineation and development programs reflect assumed individual physical characteristics of each field.

In addition to the above, model inputs include parameters that define the economic environment: world oil price, the Operator's discount rate (cost of capital), and tax rules that might pertain to future income and expenditures from Antarctic operations. The tax regime used is similar to that for offshore oil operations in the United States. The entire analysis uses constant 1988 dollars, so costs and oil prices are quoted in today's dollars, and the discount rate is measured in real terms. Subsequent inflation would affect the nominal levels of all these variables, but the net effects of these changes on profitability would largely cancel out.

The results of this modeling exercise indicate that large oil deposits (of world-class giant or larger size) could be developed in Antarctica if oil prices rise to at least double 1988 prices. Figure A-6 illustrates these results by plotting net present value (after tax) for the three field sizes in the scenarios modeled. **Only the 4-biliion-barrel supergiant field is profitable with an oil price about double the current price. The smaller fields require three to eight times current prices.**

The financial uncertainties are substantial. Will oil prices rise high enough and remain high enough to permit private operators to earn an adequate return on their investments? Box A-6 discusses four important caveats that could modify **the** results of this analysis,

Figure A-6--Oil Field Profitability



Net present value is plotted against a range of prices for three hypothetical oil fields. An oil field can be developed profitably if its net present value is greater than zero. Only the 4-billion-barrel supergiant field is profitable with an oil price about double the current price. Smaller fields would require much higher prices.

SOURCE J.L. Smith, "Profitability of Antarctic Oil Exploration and Development," OTA contractor report, December 1988.

Box A-6--Caveats

The following four caveats should be considered. They have important implications regarding the likelihood of petroleum development in Antarctica.

1. The presumed real discount rate in the analysis of 10 percent may be too low for companies contemplating large investments in highly speculative and risky projects. Although the 10 percent figure seems appropriate for investments being made in offshore petroleum provinces today, the hurdle rare for Antarctic investments could be significantly higher. The impact of higher discount rates would be to raise minimum economic prices and minimum economic field sizes, to lengthen the payback period, and to reduce the probability of substantial investments.
2. The analysis excludes the cost of most geological and seismic research that must be incurred prior to the discovery of a significant oil field. It is understood that the prospective profitability of ultimate discoveries must offset these front-end costs before sizable investments will be made in the Antarctic. Due to the long lead times that separate these early exploration costs from ultimate revenues, and the high carrying costs associated with these capital expenditures, it is safe to assume that the expectation of highly profitable oil fields will be necessary to stimulate any exploration in the Antarctic.
3. All timing assumptions (see table 2) are highly speculative, but very influential in the calculation of the profitability of individual fields. The prospect of lengthy certification or environmental permit procedures at each step will discourage private operators from attempting the process at all. Since certification and permitting procedures pertaining to Antarctica are not yet in place, it is difficult to judge the reasonableness of the time lags assumed, However, actual time lines could easily be longer.
4. The estimated cost of infrastucture in the model assumes that a single field must bear the full cost of gathering lines, transshipment terminals, and specially equipped tankers. In reality, some of these costs could be shared among several fields that might be discovered in the same area. Satellite fields, therefore, might have a lower hurdle to clear if initial discoveries cause the industry to put *some* common infrastructure in place.

OTA's analysis indicates that **the potential of Antarctic oil versus other alternatives cannot be determined with current knowledge.** Oil **from** Antarctica might *be* more or less expensive to develop than that from the Chukchi Sea or tar sands, heavy oil or oil shale, and other options. The costs to develop a particular Antarctic field will of course depend on its size, quality, and location. Some fields might be relatively inexpensive to develop, whereas others may be prohibitively expensive; the same is true for the unconventional deposits elsewhere in the world. Predictions of the costs to develop alternatives have often errored on the low side, because development costs themselves are tied to the price of oil and because proponents have portrayed their proposals in the best light.

In view of these arguments, what is the likely future for Antarctic oil development? **OTA's best guess-and it is only a guess-is that supergiant fields of 4 billion barrels or more could be developed in Antarctica by 2020 or thereabouts if such fields exist and can be found and *if* the constraints in the Minerals Convention can be overcome by a major international Operator assisted by a supportive Sponsor.**

SUMMARY

Commercial development of Antarctic oil reserves could be feasible in the next century but only if several optimistic assumptions prove out, These include technological advances; sustained, relatively high oil prices; and a reduction in excess OPEC production capacity that currently depresses the world oil market. It will also require the presence and discovery of large oil deposits, an expeditious process for resolving environmental and operating policies, and sensible and measured taxation of Antarctic oil revenues.

OTA concludes that if any one of these assumptions do not hold, oil development in Antarctica will not occur. **Under the most favorable assumptions, commercial oil development appears unlikely before three decades hence.** Early success in a concerted exploration campaign could also be critical to viable, later development.

Metal Mining in Antarctica

INTRODUCTION

Commercial mining in Antarctica, if ever allowed, would face not only the continent's harsh climate and remoteness, but also uncertainties about the geology, environment technology, legal regime, and commodity markets. The high costs of mining under these conditions would limit commercial interest to ''world class' deposits containing large amounts of very high grade ore and mineable with proven technologies. They would also probably have to be in the more accessible and/or hospitable areas of the continent.

The geology of Antarctica suggests that viable ore bodies may exist, although none have been discovered so far. So it will be some time before mining occurs, It typically takes nearly a decade or longer to find, delineate, and develop mineral deposits and meet permitting requirements. Even if exploration were to begin immediately, mining is unlikely before the next century. Given economic and political constraints, production is not expected to occur for at least two to three decades.

This appendix examines the technical and economic considerations for future Antarctic mines.[1] It assumes that the Convention will allow mining and that metals commodity prices will remain within their historic ranges. It also assumes that innovation in mining and processing technologies will continue to be evolutionary, not revolutionary. The analysis begins with a review of mining technologies now used in the Arctic, and then looks at the possibility of adapting these to Antarctica.

THE ARCTIC

Mines have been operated in severe winter climates near or north of the Arctic Circle for more than 30 years. Copper, lead, zinc, gold, silver, iron, coal, and other minerals are currently produced in the northern regions of North America, Greenland, Scandinavia, and the Soviet Union (see table B-l).

The conditions at each site differ, but all Arctic mines face low temperatures and high winds. Some mines must also contend with ice conditions that make production and transportation difficult. The weather can be so severe that roads and ports become impassable and mines and processing facilities are occasionally inoperable. Extended shut down periods (i.e., partial year operating schedules) are common. None but the richest deposits are economically attractive under these conditions. These climatic conditions require special approaches to design, operation, and maintenance in mining, processing, tailings disposal, and infrastructure support.

Mining

Open pit and underground mines, both of which exist in the Arctic, use similar approaches to the problems of cold, wind, and ice. For example, where the ground is permafrost buildings and other surface facilities are elevated or kept at subfreezing temperatures to prevent melting the ice.

Technologies used at Arctic mines have evolved to operate at -40" F and lower and in winds of 80 miles an hour and more.[2] Machinery is constructed of special steel alloys and rubber compounds, and uses special lubricants designed for cold weather use. Mobile equipment such as drills, trucks, shovels, loaders, bulldozers, and scrapers, are all furnished with heating systems and kept running continuously to prevent freezing during the severe periods of the winter. Equipment is shut down only for maintenance. Diesel fuel contains additives to permit continuous flow at low temperatures and to prevent waxing in engines. Hydraulic and electrical lines employ specially designed tubing or coatings that maintain their flexibility at low temperatures. Drilling, if necessary, is generally done dry or with a brine solution. Explosives must be designed to perform at low temperatures.

Underground Mines

Underground mining methods have been used in the Arctic for the past 100 years. Finland, Norway, and Sweden were the first to use these methods; Canada has followed in the last 10 to 15 years. Notable examples of underground mines are the Black Angel mine in Greenland and the Polaris (see box B-1), Lupin, and Nanisivik mines in the Northwest Territories of Canada.[3]

Underground mining methods generally are used for deep ore bodies where the costs of overburden removal would exceed those of developing and maintaining the required below ground facilities. In the Arctic, an additional consideration is that underground mines are for the most part protected from the wind and blowing snow.

[1] The geological factors that affect Antarctic minerals potential were discussed in ch. 4. The environmental impacts that could occur from mining operations are discussed in ch. 5. Political factors related to the adoption of the minerals convention, and the rights and assurances it affords to commercial operators and investors, are discussed in ch. 3.

[2] Magee Geological Consulting, ''Assessment of Mining and Process Technology for Antarctic Mineral Development, ' OTA contractor report, November 1988.

[3] COMINCO, ''Polaris Mine: ProductSon Success in the Rugged Arctic, ' *Mining Engineering*, *October* 1984, pp **1401-1406.** J.K. Gowans, "Producing Lead and Zinc in Canada's High Arctic,'' *AIME Preprint 84-90* (Los *Angeles,* CA: March 1984).

Table B=l-Arctic Nonfuel Mineral Facilities

Name	Location	Commodity	Company	Operation	Latitude	Status
Arctic Camp	Alaska	Cu,Pb,Zn,Ag	Bear Creek Mining Co.	SUR/MILL	N67	Exp. Prospect
Bornite	Alaska	Cu	Bear Creek Mining Co.	UG/MILL	N67	Exp. Prospect
Red Dog	Alaska	Zn,Pb,Ag	Nana Regional Corp. & COMINCO Alaska	SUR/MILL	N68	Devel. Deposit
Lik	Alaska	Zn,Pb,Ag	General Cande, Houston Div.	SUR/MILL	N68	Exp. Prospect
Lupin	Canada	Au,Ag	Echo Bay Mines Ltd.	UG/MILL	N66	Producer
Terra Operations	Canada	Ag	Terra Mines Ltd.	UG/MILL	N66	Temp. Shutdown
Coppermine River	Canada	Cu,Ag	Coppermine River Ltd.	SUR/MILL	N67	Exp. Prospect
Izok Lake	Canada	Zn,Cu,Ag,Pb	Texasgulf Inc.	SUR/MILL	N67	Devel. Deposit
Hackett River	Canada	Zn,Ag,Pb	Bathurst Norse Mines Ltd. & COMINCO Ltd.	UG/MILL	N66	Exp. Prospect
High Lake	Canada	Cu,Zn	Kennco Explorations (Canada) Ltd.	UG/MILL	N67	Exp. Prospect
Raglan Nickel Deposit	Canada	Ni	New Quebec Raglan Mines Ltd. & Others	UG/MINE	N74	Exp. Prospect
Nanisivik	Canada	Zn,Pb,Ag	Nanisivik Mines Ltd.	UG/MILL	N73	Producer
Polaris	Canada	Zn,Pb	COMINCO Ltd./Bankeno Mines Ltd.	UG/MILL	N75	Producer
Kemi	Finland	Cr	Outokumpu Oy	SUR/MILL	N66	Producer
Sokoli	Finland	Phosphate	Kemira Oy	SUR/MILL	N68	Devel. Deposit
Black Angel	Greenland	Pb,Zn,Ag	Boliden Mineral Ab & Others	UG/MILL	N71	Producer
Kirkenes	Norway	Fe	Sydvaranger A/S	PELLET PLT	N70	Producer
Mo I Rana	Norway	Fe	Norsk Jenverks A/S	PELLET PLT	N66	Producer
Bleikvassli	Norway	S	Bidjovagge Gruber A/S	MINE/MILL	N66	Temp. Shutdown
Mosjoen	Norway	Al	Mosal Aluminum	SMELTER	N66	Producer
Sulitjelma	Norway	S	Norwegian Federal Gov.	UG/MILL	N67	Producer
Skaland	Norway	Graphite	A/S Skaland Grafitverks for Atlan.Rich.	UG/MILL	N69	Temp. Shutdown
Bjornevatin	Norway	Fe	Sydvaranger A/S	SUR/MILL	N70	Producer
Svappavarra	Sweden	Fe	Luossavaara Kirunavarra (LKAB)	PELLET PLT	N68	Producer
Svappavaara	Sweden	Fe	Luossavaara Kirunavarra (LKAB)	SUR/MILL	N68	PAST Producer
Kirunavaara	Sweden	Fe	Luossavaara Kirunavarra (LKAB)	UG/MILL	N68	Producer
Viscaria	Sweden	Cu	Outokumpu Oy	UG/MILL	N68	Producer
Kiruna	Sweden	Fe	Luossavaara Kirunavarra (LKAB)	PELLET PLT	N68	Producer
Malmberget	Sweden	Fe	Luossavaara Kirunavarra (LKAB)	UG/MILL	N67	Producer
Malmberget	Sweden	Fe	Luossavaara Kirunavarra (LKAB)	PELLET PLT	N67	Producer
Aitik	Sweden	Cu,Ag	Boliden Mineral AB	SUR/MILL	N67	Producer
Laisvall	Sweden	Pb,Zn,Ag	Boliden Mineral AB	UG/MILL	N66	Producer

SOURCE: U.S. Bureau of Mines, PC-ADIT data system.

Drilling, blasting, loading, hauling, shaft or ramp haulage to surface, and ventilation systems are usually all enclosed and operate at temperatures from -20°F to near freezing. Support facilities may also be located underground for protection from the weather. Transportation permitting, yealr-round operations are usually possible.

Permafrost in the Arctic can be up to 2,000 feet thick, and ice layers can be found in the rock. However, miners have developed techniques to cope with these problems. Two examples of underground mining in which ice and mixed ice-rock is encountered are the Nanisivik and Polaris lead-zinc mines.[4]

Shaft sinking technology has improved such that it can be performed in subfreezing conditions in the Arctic with the same efficiency as elsewhere. However, special approaches may be required where ground thawing is a threat (see box B-l).

Open Pit Mines

There are few open pit mines in the Arctic. Examples are Cyprus Anvil (Fare) in the Yukon, Aitik in Sweden, and Red Dog (see box B-2), currently under development in Alaska,[5] Most open pit mines operate through the severe winter conditions. A few operations, however, are seasonal and may shut down for 3 to 4 months of the winter. This is done more because of the workers' limited ability to function at the sustained low temperatures than the equipments' performance under these conditions.

Open pit mines are, by definition, exposed to the weather, so they must contend with very low temperatures in the Arctic. Of major importance is the ability of

[4]S. Dayton, "Bolidcn Takes a Qua-tying Concept Underground at One of Europe's Larger Lead Mines," *E&MJ*, February 1981, pp. 67-73. R. Fish, "The Place Where People Find Things—Nanisivik Mines in Canada's High Arctic,' *Canadian Mining Journal,* *September 1978,* pp. *344 Shaf*

[5]J.C. Hopkins, "Galvanizing the Anvil," *Canadian Mining Journal,* August 1986, pp. 17-18. L. White, "Copper from the Swedish Arctic," *E&MJ*, February 19S4, pp. 29-33. H.M. Giegerich. "Progress Repot-I on COMINCO's Red Dog Project in Alaska, Second Largest Zinc Deposit Ever Discovered," *Mining Engineering*, December 1986, pp. 1097-1101.

Box B-1—Polaris: An Arctic Underground Mine[1]

The Polaris lead-zinc mine (75° N. latitude) is located on Little Cornwallis Island, Northwest Territories, Canada near the settlement of Resolute Bay. It is owned and operated by Vancouver-based COMINCO, Ltd. and is the western world's most northerly base metal-mine.

had-zinc mineralization was discovered on Little Cornwallis Island in 1960. In 1972, following 10 years of exploration and several years of core drilling, the sizable ore body was confirmed. The ore assays at 12 percent zinc and 3 percent lead (compared with an average of 5.9 percent zinc and 2.4 percent lead at zinc mines worldwide).[2] In 1979, after 5 years of engineering and environmental feasibility studies, COMINCO announced it would proceed with development of the mine. Construction began in 1980 and was completed by 1982 at a cost of about $125 million and roughly $35 million in working capital.[3] It has operated continuously and profitably since.

Temperature extremes range from a winter low of -58° F to a high of 59°F in August. Continuous darkness prevails from November through February, and continuous daylight exists from April to August. Freeze-up begins in September. Offshore, ice thickness increases from 1 foot in October to 7 feet in May. The permafrost extends to a depth of approximately 1,400 feet. Only the top few inches thaw in the summer.

The major feature of mining at Polaris is the absolute necessity of preventing thawing. Because the entire ore body is located in permafrost, the ore is porous and the voids contain ice. If allowed to thaw, the stability of the mine openings would severely deteriorate. To ensure freezing conditions, four refrigeration units are used in the summer to cool the ventilation air. In the winter, the natural -25°F ventilation compensates for the heat generated by the mining equipment. Inhibiting thawing also extends to the backfilling operation. In many underground mines, the backfill material is mill tailings combined with cement, Mill tailings would add too much heat to the Polaris mine, so shale mined at the surface is used instead. A small amount of fresh water is added to this fill to freeze it in place for stability.

Polaris is located on the coast, so the need for roads was limited to those at the mine site. The mill was constructed on a barge in southern Canada and towed to the mine site. At high tide, the barge was floated into a prepared lagoon and berthed. The lagoon was then backilled. The 100 foot by 400 foot multilevel barge houses the concentrator, power generator, maintenance shops, offices, assay lab, warehouse, and fuel oil storage.

The concentrates are stored in an unheated building with a capacity for 220,000 tons of concentrates. The shipping season at Polaris is normally 6 weeks long, from mid-August to the end of September. During this period, the year's production of concentrates must be shipped out, and all supplies except perishable foods must be received. The concentrates are shipped primarily to Europe for smelting and refining. Air service via Resolute Bay is available for personnel and food.

Mill tailings are disposed in Garron Lake. They are pumped 1.6 miles to the lake, where they are thickened and pumped deep below the lake surface. Garron Lake provides an acceptable environment for depositing the tailings due to its meromictic character (no vertical circulation of the water). Below 66 feet, there exists a zone with three times the salinity of seawater that contains naturally occurring hydrogen sulfide. This precipitates any soluble heavy metals in the tailings slurry.

COMINCO has engineered a system which captures 93 percent of the energy value of the fuel oil burned to generate power. Waste heat from the electric generator is used to dry the concentrates and provide space heating. The accommodations for the 200 workers are designed to provide as attractive an environment as possible. There are four living modules plus modules for administration, dining, recreation, and service. The modules are positioned 5 feet off the ground to prevent thawing of permafrost. The recreation facility includes numerous indoor sports facilities, including a swimming pool. The southern (non- Inuit) personnel work continuously for 10 weeks and then have 2 or 3 weeks off. Most are flown to their homes in Montreal, Toronto, Edmonton, Yellowknife, or elsewhere across Canada.

[1] Taken primarily from "ASSaSXIIa[of Mining and Process Technology for Antarctic Mineral Development," November 1988, contractor report prepared for OTA by Magee Geological Consulting.

[2] *An Appraisal of Minerals Availability for* 34 *Commodities*, Bulletin 692, Bureau of Mines, U.S. Department of the Interior (Washington, DC 1987).

[3] Maarten J, de Wit, *Minerals and Mining* 01 *Antarctica, Science and Technology, Economics and Politics* (Oxford: Clarendon Press, 1985)

personnel to function efficiently at the sustained low temperatures that are encountered. Many operations, such al drilling, loading explosives, and blasting must be performed with personnel exposed to severe cold. Surveying, sample handling, secondary blasting, and other functions typically have to be performed outdoors.

Dredging

Dredging is another mining technology used occasionallv in the Arctic. Alluvial deposits in shaIlow water are dredged during the summer in Alaska and the Yukon. One large gold dredge operates off the coast of arctic Alaska near Nome for about 5 months of the year,

The Polaris Mine at 75" N. latitude in the Canadian Arctic.

Processing

After an ore is mined, various processing steps are used to extract the valuable metals or minerals it contains. Depending on the mineral, some combination of crushing, grinding, beneficiation, smelting, refining, or hydrometallurgical processing are needed. Part of the processing is normally done at the mine site, the remainder is done elsewhere. The extent of mine-site processing depends on the costs of transporting products and raw materials and those of constructing and operating a processing facility. For an easily processed ore, such as gold, all processing may be performed at the mine site. Arctic gold mines commonly have small furnaces and make gold bars. Base metal mines in the Arctic, however, include only a mill (crushing, grinding, classification, and concentration). The concentrates are shipped elsewhere for smelting, refining, or hydrometallurgical processing. This particular configuration is chosen because:

- transporting ore that is of low value per ton to distant mills is prohibitively expensive;
- smelting economies-of-scale are such that few mines are large enough to support a competitive smelter
- transporting processing fuel oil, fluxes, and other supplies to the mine site is costly and further strains the already short shipping season; and
- there are no proven hydrometallurgical processes for nonferrous metals which are economically viable on a small scale.

Common forms of beneficiation have been used in the Arctic for copper, zinc, lead, and platinum group metals.[6] The important feature in designing crushing circuits is to keep ore from thawing and refreezing. For example, at the Polaris mine, primary crushing takes place underground at below freezing temperatures. Most Arctic grinding circuits are located in a heated building. Flotation and other concentration circuits are always located in heated buildings.

Tailings Disposal and Water Treatment[7]

The selection of a disposal method for mill tailings is a very site-specific decision. All Arctic mills have had to meet stringent environmental limitations, and in the case of newer operations ''zero discharge' is the goal. Red Dog uses a tailings dam and discharged water is treated to remove heavy metals. Mill tailings at the Polaris mine are discharged into a lake where the high salinity coupled with the naturally occurring hydrogen sulfide precipitates the soluble heavy metals contained in the tailings pulp. At Black Angel, where the tailings are discharged to the bottom of a fjord, the original disposal system resulted in lead contamination of the local marine life to the extent that certain mussels were not suitable for consumption. Black Angel has since adjusted its milling process to reduce the heavy metal content (dissolution) of its mill waste, and increased the thoroughness of its *tailings* treatment operations. The technical aspects of land-based tailings disposal can be resolved, as shown by the methods used at Lupin and proposed for Red Dog. However, because of the need for earthen darns and additional water treatment capacity, disposal on land is expected to become more expensive than ocean disposal.

Infrastructure Support

Mining requires a great deal of supporting infrastructure, including power, water, roads, and sometimes railroad and shipping facilities. In addition, airfields and personnel accommodations are required at remote mines. Most of the mining camps developed in the Arctic of Norway, Sweden, and Finland had some nearby manpower, roads, port facilities, and power available within 100 miles. Because North American Arctic mines are more remote, more infrastructure had to be constructed specifically for them. In general, governments have been supportive of mine development in the far north, and have at times assisted with infrastructure financing (e.g., Nanisivik in Canada).

Power at most Arctic mines is generated by diesel fuel. This requires large amounts of fuel (on the order 4 million

[6]Platinum group metals include platinum, palladium, rhodium, ruthenium, iridium, and osmium.
[7]Magee @-@K@ Consulting, op. cit., footnote 2.

Box B-2—Red Dog: An Arctic Open Pit Mine[1]

The Red Dog deposit (68° N latitude) is located in northwest Alaska near the Kotzebue Sound and the Chukchi Sea. The deposit contains 85 million tons of ore assaying 17.1 percent zinc, 5 percent lead, and 2.4 troy oz./ton silver. COMINCO, Ltd. is developing the mine, which will be the world's largest zinc producer when it starts production. The 6,000 short ton/day project is being built at a cost of $300 million, plus an additional $175 million for a port and the access road from the port to the mine.[2] Production is scheduled to begin in late 1989.

The operation will consist of an open pit mine, a mill, concentrate storage buildings, tailings disposal facilities, maintenance shop, a power facility, road and port facilities, and accommodations and recreation facilities for 300 people.

The mine will be a conventional open pit mine with 10-cubic-yard loaders and 50-to 85-ton haul trucks. Due to the minimum amount of waste which overlays the deposit, preproduction stripping is limited to several million tons; the life-of-mme strip ratio should be very low (1.0 or less).[3] A key element in the design of the pit is the placement of the waste rock. Weathering of the deposit outcrop has caused heavy metals to enter Red Dog Creek. The mine plan calls for positioning the waste dumps to minimize the potential for additional natural leaching of heavy metals from this weathered outcrop material, which will not be processed initially.

The mill will incorporate the latest technology in order to minimize space requirements, maximize energy efficiency, and improve recovery. The basic unit operations of the mill will be primary crushers; semi-autogenous (SAG), ball, and tower mills; Maxwell and column flotation cells; and pressure filters. The SAG mills are used to eliminate fine crushing with its inherent material-handling problems for wet or frozen ore. The concentrates will be filtered using pressure filters, thus making it unnecessary to further dry the concentrates.

The mill tailings will be disposed behind a tailings dam constructed from material excavated from the mill site. The dam will be raised in stages over the life of the mine. Excess water and run-off water will be treated for removal of heavy metals prior to discharge to Red Dog Creek.

Power will be generated onsite, and the waste heat will be used to heat the process buildings, accommodation building, and incoming water. Those surface facilities which do not house process equipment will be pre-engineered buildings erected on site. The main mill facility and the accommodation building will be constructed of modules that have been preassembled in the United States or Asia. These modules, weighing up to 1,500 tons will then be transported by barge to the Red Dog port and hauled to the mine site.

The Red Dog mine is inland, so ground transportation has to be available. A 52-mile all-weather road (including 10 bridges) from the port to the mine is being built at a cost of $2 million per mile. Concentrates out of, and supplies into, the mine will be transported with 150-ton trucks.

The Red Dog shipping season is estimated to be 100 days. The port facilities are limited by shallow water. Self-unloading barges will be required to transport the concentrates to offshore ships. The concentrates will be shipped to North America. Japan, South Korea and Europe for smelting and refining.

[1]IT&m primarily from ''Aaseaamcmt of Mining and Process Technology for Antarctic Mineral Development,' November 1988, report prepared for OTA by Magee Geological Consulting.

[2]The port and road are to be financed by the State of Alaska.COMINCO will pay a toll fee of $17 per ton to transport the concentrates

[3]Strip ratio is the tonnage of waste rock that must be removed for every ton of ore extracted. Since waste removal is costly, low strip ratios enhance the viability of mines.

gallons per year at Polaris) to be transported north. The fuel is brought by truck or ship. Fuel transport by ship is seasonally limited at the coastal Polaris and Black Angel mines and can require the use of ice breakers or reinforced cargo vessels.

Road construction has been a major cost in some Arctic areas. The Lupin mine in the Northwest Territories has a winter road built on snow and lake ice. Supplies can move along this road only during the winter months. This road is 360 miles long, including 330 miles of ice roads across frozen lakes. The road can be used for about 3 months of the year, during which time essentially all fuel and supplies for the next 9 months are transported. The Red Dog mine in Alaska is presently under construction, and a 52-mile access road to a port facility has been built across permafrost at a cost of $2 million per mile.

Materials handling at the mine, mill, storage, and port facilities is another important consideration in Arctic mining operations. Special consideration during cold weather is required to prevent inappropriate freezing of ores, waste, tailings, slurry lines, conveyors, and concentrates.

Air transport is essential for rapid movement of personnel and related perishable food and emergency supplies. It is also essential during the construction phase to reduce construction time and costs. Each site must have a maintained airfield. Year-round operations must have an airfield designed for severe weather conditions.

Building construction in the Arctic is most often modular. Building and equipment modules are built in more temperate regions and transported to the mine site for final assembly. Module construction for infrastructure was done at Polaris and Lupin and is underway for the Red Dog mine in Alaska. In a unique design for Polaris, the entire processing plant was built on a barge, towed to a dredged basin at the site, and permanently moored in place.[8]

Accommodations for personnel are required at the remote Arctic mines. These quarters include recreational and communications facilities for the workers. Waste heat from the generator systems is used for surface facility and plant heating in the Arctic.

Economics

The technology developed by the mining industry has proved functional in severe Arctic conditions. The costs associated with the special approaches to mining, processing, tailings disposal, and infrastructure support are greater than in lower latitudes, but the mines have been economic because of their higher grade ores. The ore at Polaris averages 12 percent zinc, whereas ore grades at zinc mines worldwide average 5.9 pecent.[9] Coproduct values may also be important. For example, the ore in the Red Dog deposit not only assays 17.1 percent zinc, but also contains 5 percent lead and 2.4 troy oz./ton silver.

Table B-2 shows the difference in ore grade and operating costs for selected Arctic and southern mines. For the mines listed in the table, the average operating costs of both underground and open pit mines in the Arctic are more than twice as high as comparable mines further south. Ore grades are also significantly higher than for southern mines. Arctic deposits typically contain in situ ore valued at more than $200 per ton.[10] The risks inherent in Arctic mining lead companies to require a return on their Arctic investments of 20 percent or more, compared with a 15 percent hurdle rate elsewhere.

Another consideration affecting the economics of Arctic mines is the size of the deposits. Because of the large capital costs involved, a deposit must be very large and have suitable production to recover the investment. For example, the Red Dog mine, with 85 million tons of ore, will be the largest zinc mining operation in the world when it reaches production. The capital cost is estimated at $300 million not including the port and 52-mile access road to the mine, which are being built by the State of Alaska for $175 million. At full capacity, the mine is designed to operate at a rate of 6,000 tons of ore per day.

Location is another economic consideration, particularly with regard to transportation infrastructure. Occasionally, a deposit which may not be quite rich enough or large enough to be developed independently may, through fortuitous location, become more economically attractive by utilizing nearby infrastructure developed for another deposit. For example, the Lik deposit, 12 miles northwest of the Red Dog deposit may not have been as economically attractive on its own as it is with the nearby Red Dog deposit being developed. Thus far, the Lik deposit has drilled reserves of approximately 24 million tons assaying 9 percent zinc, 3 percent lead, and 1.4 troy oz./ton silver.

ANTARCTICA

Environment

The Antarctic environment is perhaps the first factor that would affect the viability of a mining venture. Antarctica is the coldest, highest, windiest, and most isolated continent on Earth. In addition, it has a cover of ice that limits rock exposure to about 100,000 square miles, or one-fiftieth of the total area of the continent. The Antarctic Peninsula reaches within 500 miles of the tip of South America, but in other sectors the closest land is some 1,400 miles distant.[11]

The isolation and ice cover create an environment more severe than that in the Arctic, and mines would need to be designed to withstand low temperatures, high winds, and harsh storms. The mean temperatures in the coastal areas range from about +32°F (in the warm months) to 0°F to -20°F (in the cold months). The interior, high polar plateau, is much colder, with mean temperatures of about -40°F in the warm months and as low as -90°F in the cold months. The northwestern part of the Antarctic Peninsula is milder because of its maritime climate; winter mean temperatures are +15 “F, and winds over its central part are persistent but not fierce.

[8] J.K. @wi n, ‘‘The Polaris Process Barge,’ *CIM Bulletin*, April 1983, pp. 93-97.

[9] *An Appraisal of Minerals Availability for 34 Commodities*, Bulletin 692, Bureau of Mines, U.S. Department of the Interior (Washington, DC: 1987).

[10] In situ ore value (measured in $/ton) equals the amount of metal(s) contained in a ton of ore multiplied by the price of the metal(s). This value must be sufficient to cover all the operating costs and depreciated capital costs of recovering the metal(s) and getting it to market.

[11] D.H. Elliot, Director, *A Framework for Assessing Environmental Impacts of Possible Antarctic Mineral Development* (Institute of Polar Studies, The Ohio State University, 1987).

Table B-2—Lead/Zinc Producer Comparisons

Name	Mine type	Ore grade (%) Zinc	Lead	Estimated operating costs[a] ($/ton)
Northern:				
Red Dog	Open pit	17	5	27
Polaris	Underground	12	3	27
Nanisivik	Underground	12	1	30
Southern:				
Buick	Underground	1.6	5.9	12
Mount Isa	Underground	6.5	6.4	19
Elmwood	Underground	3.0	0.0	11

[a]Costs are estimates based on past surveys of lead/zinc producers. Though not current, they illustrate the differences between northern and southern mines.

SOURCE: Magee Geological Consulting, "Assessment of Mining and Process Technology for Antarctic Mineral Development," OTA contractor report, November 1988.

Storms are frequent, even in the milder coastal areas. Stormy conditions result from either surface flow of air from the continental interior (katabatic winds that are exceptionally violent in some coastal areas) or the passage of low pressure systems. Depressions are generated frequently in a circum-Antarctic belt between *70°* and *60°* latitude South, and strong westerly winds occur on the northern flank of this belt. Individual depressions may form in less than a day and as many as six depressions in various stages of growth and decay may occur at any one time around the continent. These centers may follow one another with greater frequency than is experienced in the Northern Hemisphere belt of westerlies, and there is little assurance of calm conditions between successive centers. The southern parts of the depressions frequently penetrate the coastal regions of Antarctica and bring strong winds, blizzards, and heavy snowfall.

An Antarctic mine may have more difficulty accommodating the moving glacier ice than coping with the weather. The ice sheet presents a formidable challenge to designing a mining system. It forms a slow-moving carapace whose thickness in places exceeds 13,000 feet.[12] The ice cover restricts rock exposures to coastal regions and to the summits of isolated peaks (e.g., in the Transantarctic and Ellsworth Mountains). At present no system to mine through this ice is considered economically feasible, It will also be prudent to avoid building a port and road system on moving ice. Resupply may also be a serious problem in Antarctica-many thousands of tons of fuel and other supplies must be brought to a mining operation. Interior areas would be the most difficult to resupply.

Logistical support for an Antarctic mine would be hampered by the coastal ice shelves. Moreover, Antarctica is physically isolated by a pack ice belt that seasonally extends 900 miles from the continent in some locations. The minimum sea ice cover occurs in March, but by September sea ice cover has grown to nearly 8 million square miles. The sea ice consists of individual floes 30 to 300 feet across and up to 10 feet thick. In spring and summer, however, the sea ice drifts northward and melts, and open water is encountered along many coastal areas.

Mineralization

Moderate climate, accessibility, and available knowledge about mineral deposits suggest that the most promising area for mining is the Antarctic Peninsula. The Peninsula has received the most attention from geologists, in part because theories point to possible deposits there and because sampling is easier there than elsewhere. Because parts of the Peninsula are accessible and more moderate in climate, they may be promising enough for initial minerals prospecting.[13]

Mining

A mine in Antarctica's interior (for instance on the Dufek Massif) would face much greater isolation and probably a harsher climate than is experienced at Arctic mines. Such conditions would probably require substantial improvements in existing technologies, if not completely new technologies, and would likely require extraordinarily high valued ore. In the coastal regions, however—especially the Antarctic Peninsula—environmental conditions are similar to those of existing mining operations in the Arctic. An Antarctic mine in

[12]The ice flows out toward the coast, calving as glaciers into the sea or becoming part of the floating ice shelves such as the Ross Ice Shelf. The ice shelves are the source of the large tabular icebergs.

[13]OTA Workshop on Antarctic Mining Technology and Economics, Dec. 13, 1988.

these areas would probably use similar technology and operating techniques.

The Antarctic Continent offers some special conditions not found in areas near mines of the Arctic. About 98 percent of the continent is covered by ice (which makes it similar to northern Greenland), so mines must be located in exposed or nearly exposed areas. Mine construction would have to start in an exposed area but may extend under ice cover. It would be impractical initially to locate mine shafts on ice and to sink shafts and declines through the ice to a deposit below. Shafts, ramp declines, or other underground mine access points, including ventilation raises, initially would have to be located on solid ground. Similarly all plant sites and support facilities would have to be located on the ground or underground. A plan for dealing with ice and for siting the surface plant and infrastructure must be addressed at the time of mine design. Temporary buildings may be located on ice, but if the ice is moving, even this is not practical. Land areas suitable for mine locations will be difficult to find. It will be necessary to drill and blast to establish level surface areas for mine access and plant and infrastructure construction in rugged areas such as the Dufek Massif and the Copper Nunatak in the Antarctic Peninsula. Alternatively, some of these facilities could be located in underground excavations.

Underground Mining

The conditions for underground mining in Antarctica may be similar to those in the Arctic. However, rock temperatures and permafrost depths may differ. Nonetheless, several underground mining methods that have been used in the Arctic might be applicable in Antarctica. For example, a room and pillar method might be used for a flat lying platinum deposit (a possibility in the Dufek igneous complex).

Open Pit Mining

The open pit mining method may be suitable in selected areas of Antarctica, the most likely being the northern Antarctic Peninsula and the Dry Valleys near McMurdo Station. It may be used in select areas where ice cover is less than 500 to 600 feet thick. Mining an ore deposit through thicker ice cannot be done by conventional methods, and open pit mining of a deposit below the ice is highly unlikely. There are no examples in the northern latitudes of open pit mining through a glacier or ice field. Ice accumulations have been mined in Canada in and around open pit mines, but nothing comparable to mining extensive ice areas. More research and investigation will be needed before any system to undertake open pit mining beneath the Antarctic ice cap can be contemplated. However, it does appear possible to remove some ice over an ore deposit by open pit mining methods.

Dredging

Dredging operations would be infeasible in much of Antarctica because of ice conditions. Some areas, though, have conditions suitable for at least seasonal dredging. One such area is the northern part of the Antarctic Peninsula. However, it is not certain what mineral resources exist there.

Processing

Processing in Antarctica would probably face the same problems and constraints as those encountered in the Arctic. Most likely, milling would be performed at the mine site, and the concentrates would be shipped to a northern smelter or hydrometallurgy plant. Energy efficiency in the milling process would take on added importance, because of costliness of bringing in fuel oil. Solar energy may have application because of 24-hour daylight in summer.

Tailings Disposal

Tailings from mill processing of ores would likely be contained on land surface areas, but if land surface is in short supply, tailings may be disposed on the ice. This material would freeze and, assuming no thawing of the ice, should present no future problem, Excess water could be recycled from the tailings. This is only one of a variety of possible methods for tailing disposal. All have some drawbacks, either technical or economic, and the disposal of tailings probably poses one of the most serious environmental problems in a mining operation (see ch. 5).

Infrastructure Support

Constructing the infrastructure for Antarctic mining would be more difficult and costly than in the Arctic given the longer distances from major staging areas and the moving ice. Transportation of fuel and concentrates as well as personnel and supplies would be perhaps the most difficult and costly task. New or modified transport technologies may have to be developed. Mining and processing initially may be seasonal operations for lack of year-round infrastructure,

The transportation of fuel and concentrates for a base metal operation would probably require ships. A port that is at least seasonally ice-free would be needed,[14] but port facilities would be expensive and difficult to locate. Arctic mining projects have used ice-reinforced ships and barges as well as newly built, dedicated port facilities. Ice-free periods are one to a few months' duration so

[14] Water transportation may not be required for high value, low volume products such as gold and platinum. These products may possibly be shipped by air.

product stockpiles need to be built up for use during the winter season, Port conditions in Antarctica may be similar to those in the Arctic but with the added difficulty of longer transits to a supply base, much stormier weather, and locally higher occurrences of icebergs in the open water.

Overland transportation of fuel, supplies, and product would be one of the major costs of an inland mining operation. A site at the Dufek Massif may require about 330 miles of ice ''road' across the Ronne Ice Shelf to the site. Any discovery in Antarctica inland from the coast would require the construction of an ice road for access, except perhaps in the islands near the Northern Antarctic Peninsula and the Northern Peninsula itself. Such construction and maintenance may well be a major and costly task. Maintaining winter access along such a road may be impossible where high winds and blowing snow could make passage unsafe.

Fuel may be transported by pipeline, but with subfreezing temperatures prevailing, a pipeline would have to be suspended and heated. Since a road would have to be maintained for other supplies, a pipeline for fuel may not be a justifiable added cost.

Air transportation would be required for personnel, small supplies, and possibly product shipment in the case of gold or platinum. Environmental conditions affecting air service to Antarctic regions near the coast may be similar to the Arctic, but inland, they may be much more severe. Extreme cold temperatures, high winds, and blowing snow in inland Antarctic regions could severely restrict aircraft operations, and this could affect the ability of a mine to operate year-round. Large, wheeled aircraft have made numerous landings on unprepared blue-ice patches in interior parts of the continent, suggesting that use of such aircraft may be viable in some areas during the austral summer.

Accommodations for personnel can be designed in a manner similar to those in the Arctic examples cited and should be satisfactory, but should be designed to withstand the high winds anticipated. If a year-round operation is planned, crew transfers from the site by air during much of the year will be needed. Air service in all conditions is probably not possible. This means that an airfield must be constructed that can function during almost all weather conditions, a very difficult task in most areas of Antarctica.

Economics

Several studies and a number of speculations have focused on the feasibility of mining platinum from the Dufek Massif.[15] The many technical problems encountered at this site in Antarctica's interior appear insurmountable to some experts, The studies speculate that mining may occur in this and other Antarctic sites if agreements are reached to encourage such development and if high-grade deposits are located. OTA finds that past studies that concluded mining platinum from the Dufek Massif was practical underestimated the costs and difficulties involved.[16]

OTA investigated the relative levels of difficulty of mining in the Arctic and Antarctic. **Mining in Antarctica would not only be more expensive than that in the Arctic, but the enhanced risks would require even greater financial returns to the investors. Antarctic mining might require an estimated 30 percent return, compared with 20 percent in the Arctic, and 15 percent elsewhere.** The in situ value of the Arctic Red Dog and Polaris ores are **$290** and **$200** per ton, respectively.[17] Deposits in Antarctica must have at least this value for mining to be economic. OTA concludes that to cover these costs, ore values would need to be about $200 to $400 per ton for a commercial Antarctic Peninsula mine, and about $300 to $600 per ton for a Dufek Massif mine. These values (at today prices) mean that a Peninsula gold deposit would need to contain an ore with between 1/2 and 1 ounce of gold per ton and a Dufek platinum deposit would need to contain the same grades of platinum per ton.[18] Ores of these high grades are rare and any lesser grade ores would probably not be developed. Though this conclusion is highly speculative, it appears reasonable given the limited state of current knowledge.

SUMMARY

OTA has not developed a separate, complete scenario for a hypothetical Antarctic mine because large numbers of variables make any detailed technical or economic approach impractical. Instead, the foregoing discussion presents possible general approaches. It indicates that certain high-grade mineral deposits could probably be mined economically in Antarctica if they were located in reasonably accessible areas. Mining on the coast or on the Peninsula might be done with the technologies currently used in the Arctic. Technology would not be a significant

[15] See, for example, M.J. de Wit, *Minerals and Mining in Antarctica Science and Technology, Economics and Politics* (Oxford: Clarendon Press, 1985). See also, The Institute of Polar Studies, *A Framework for Assessing Environmental impacts of Possible Antarctic Mineral Development,* Ohio State University, 1977.

[16] Magee Geological Consulting, op. cit., footnote 2.

[17] supra note 15

[18] A grade of approximately four times the grade of the example in the de Wit study.

deterrent to minerals development in these ice-free, accessible locations with ''Arctic-like' environments. Economics, however, could be a major deterrent. The deposit would have to be of "world class" value to cover the high costs of the facility and its infrastructure and the large financial returns needed to compensate the investors for the additional risks.

The situation is different for a mine in the Antarctic interior (including the Dufek Massif). Here, the climate, ice, and remoteness may require substantial improvements in existing technologies, if not completely new technologies. Considering the other risks in developing an Antarctic mine, mining firms and their financial backers would be hesitant to adopt unconventional mining and metallurgical processes. Initially only proven processes are likely to be acceptable. Therefore, mining in Antarctica's interior is not expected soon, if ever.

Most U.S. mining industry representatives have not given much, if any, attention to Antarctic minerals. Those that have paid some attention consider the political and institutional risks to be the principal deterrent to future Antarctic minerals development.[19] They are pessimistic about operating under the regulatory framework of the Minerals Convention and the uncertainties of jurisdiction, taxation, permitting procedures, environmental rules, etc.[20] Further discussion of industry views on the acceptability and workability of the Convention are covered in chapter 3.

[19] OTA Workshop, Dec. 13, *1988;* Keith R. Knoblock, Vice President, American Mining Congress, personal communication, Dec. 15, 1988,

[20] Simon D. Strauss, Consultant on Metal Markets, personal communication, Apr. 13, 1989.

Appendix C

The Antarctic Treaty
Adopted at Washington 1 December 1959

The Governments of Argentina, Australia, Belgium, Chile, the French Republic, Japan, New Zealand, Norway, the Union of South Africa, the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland, and the United States of America,

Recognizing that it is in the interest of all mankind that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord;

Acknowledging the substantial contributions to scientific knowledge resulting from international cooperation in scientific investigation in Antarctica;

Convinced that the establishment of a firm foundation for the continuation and development of such cooperation on the basis of freedom of scientific investigation in Antarctica as applied during the International Geophysical Year accords with the interests of science and the progress of all mankind;

Convinced also that a treaty ensuring the use of Antarctica for peaceful purposes only and the continuance of international harmony in Antarctica will further the purposes and principles embodied in the Charter of the United Nations;

Have agreed as follows:

Article **1**

1. Antarctica shall be used for peaceful purposes only. There shall be prohibited, inter alia, any measures of a military nature, such as the establishment of military bases and fortifications, the carrying out of military manoeuvres, as well as the testing of any type of weapons.

2. The present Treaty shall not prevent the use of military personnel or equipment for scientific research or for any other peaceful purpose.

Article 2

Freedom of scientific investigation in Antarctica and cooperation toward that end, as applied during the International Geophysical Year, shall continue, subject to the provisions of the present Treaty.

Article 3

1. In order to promote international cooperation in scientific investigation in Antarctica, as provided for in Article 2 of the present Treaty, the Contracting Parties agree that to the greatest extent feasible and practicable:

(a) information regarding plans for scientific programs in Antarctica shall be exchanged to permit maximum economy and efficiency of operations;

(b) scientific personnel shall be exchanged in Antarctica between expeditions and stations;

(c) scientific observations and results from Antarctica shall be exchanged and made freely available.

2. In implementing this Article, every encouragement shall be given to the establishment of cooperative working relations with those Specialized Agencies of the United Nations and other international organizations having a scientific or technical interest in Antarctica.

Article 4

1. Nothing contained in the present Treaty shall be interpreted as:

(a) a renunciation by any Contracting Party of previously asserted rights of or claims to territorial sovereignty in Antarctica;

b) a renunciation or diminution by any Contracting Party of any basis of claim to territorial sovereignty in Antarctica which it may have whether as a result of its activities or those of its nationals in Antarctica or otherwise;

(c) prejudicing the position of any Contracting Party as regards its recognition or non-recognition of any other State's right of or claim or basis of claim to territorial sovereignty in Antarctica.

2. No acts or activities taking place while the present Treaty is in force shall constitute a basis for asserting, supporting or denying a claim to territorial sovereignty in Antarctica. No new claim, or enlargement of an existing claim, to territorial sovereignty in Antarctica shall be asserted while the present Treaty is in force.

Article 5

1. Any nuclear explosions in Antarctica and the disposal there of radioactive waste material shall be prohibited.

2. In the event of the conclusion of international agreements concerning the use of nuclear energy, including nuclear explosions and the disposal of radioactive waste material, to which all of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article 9 are parties, the rules established under such agreements shall apply in Antarctica.

Article 6

The provisions of the **present Treaty** shall apply to the area south of 60 degrees South Latitude, including all ice shelves, but nothing in the present Treaty shall prejudice or in any way affect the right, or the exercise of the rights, of any State under international law with regard to the high seas within that area.

Article 7

1. In order to promote the objectives and ensure the observance of the provisions of the present Treaty, each Contracting Party whose representatives are entitled to participate in the meetings referred to in Article 9 of the Treaty shall have the right to designate observers to carry out any inspection provided for by the present Article. Observers shall be nationals of the Contracting Parties which designate them. The names of observers shall be communicated to every other Contracting Party having the right to designate observers, and like notice shall be given of the termination of their appointment.

2. Each observer designated in accordance with the provisions of paragraph 1 of this Article shall have complete freedom of access at any time to any or all areas of Antarctica.

3. All areas of Antarctica, including all stations, installations and equipment within those areas, and all ships and aircraft at point of discharging or embarking cargoes or personnel in Antarctica, shall be open at all times to inspection by any observers designated in accordance with paragraph 1 of this Article.

4. Aerial observation may be carried out at any time over any or all areas of Antarctica by any of the Contracting Parties having the right to designate observers.

5. Each Contracting Party shall, at the time when the present Treaty enters into force for it, inform the other Contracting Parties, and thereafter shall give them notice in advance, of

(a) all expeditions to and within Antarctica, on the part of its ships or nationals, and all expeditions to Antarctica organized in or proceeding from its territory;

(b) all stations in Antarctica occupied by its nationals; and

(c) any military personnel or equipment intended to be introduced by it into Antarctica subject to the conditions prescribed in paragraph 2 of Article 1 of the present Treaty.

Article 8

1. In order to facilitate the exercise of their functions under the present Treaty, and without prejudice to the respective positions of the Contracting Parties relating to jurisdiction over all other persons in Antarctica, observers designated under paragraph 1 of Article 7 and scientific personnel exchanged under sub-paragraph l(b) of Article 3 of the Treaty, and members of the staffs accompanying any such persons, shall be subject only to the jurisdiction of the Contracting Party of which they are nationals in respect of all acts or omissions occurring while they are in Antarctica for the purpose of exercising their functions.

2. Without prejudice to the provisions of paragraph 1 of this Article, and pending the adoption of measures in pursuance of sub-paragraph l(e) of Article 9, the Contracting Parties concerned in any case of dispute with regard to the exercise of jurisdiction in Antarctica shall immediately consult together with a view to reaching a mutually acceptable solution.

Article 9

1. Representatives of the Contracting Parties named in the preamble to the present Treaty shall meet at the City of Canberra within two months after the date of entry into force of the Treaty, and thereafter at suitable intervals and places, for the purpose of exchanging information, consulting together on matters of common interest pertaining to Antarctica, and formulating and considering, and recommending to their Governments, measures in furtherance of the principles and objectives of the Treaty, including measures regarding:

(a) use of Antarctica for peaceful purposes only;

(b) facilitation of scientific research in Antarctica;

(c) facilitation of international scientific cooperation in Antarctica;

(d) facilitation of the exercise of the rights of inspection provided for in Article 7 of the Treaty;

(e) questions relating to the exercise of jurisdiction in Antarctica;

(f) preservation and conservation of living resources in Antarctica,

2. Each Contracting Party which has become a party to the present Treaty by accession under Article 13 shall be entitled to appoint representatives to participate in the meetings referred to in paragraph 1 of the present Article, during such time as that Contracting Party demonstrates its interest in Antarctica by conducting substantial scientific research activity there, such as the establishment of a scientific station or the dispatch of a scientific expedition.

3. Reports from the observers referred to in Article 7 of the present Treaty shall be transmitted to the representatives of the Contracting Parties participating in the meetings referred to in paragraph 1 of the present Article.

4. The measures referred to in paragraph 1 of this Article shall become effective when approved by all the

Contracting Parties whose representatives were entitled to participate in the meetings held to consider those measures.

5. Any or all of the rights established in the present Treaty may be exercised as from the date of entry into force of the Treaty whether or not any measures facilitating the exercise of such rights have been proposed, considered or approved as provided in this Article.

Article 10

Each of the **Contracting** Parties undertakes to exert appropriate efforts, consistent with the Charter of the United Nations, to the end that no one engages in any activity in Antarctica contrary to the principles or purposes of the present Treaty.

Article 11

1. If any dispute arises between two or more of the Contracting Parties concerning the interpretation or application of the present Treaty, those Contracting Parties shall consult among themselves with a view to having the dispute resolved by negotiation, inquiry, mediation, conciliation, arbitration, judicial settlement or other peaceful means of their own choice.

2. Any dispute of this character not so resolved shall, with the consent, in each case, of all parties to the dispute, be referred to the International Court of Justice for settlement; but failure to reach agreement on reference to the International Court shall not absolve parties to the dispute from the responsibility for continuing to seek to resolve it by any of the various peaceful means referred to in paragraph 1 of this Article.

Article 12

1. (a) The present Treaty maybe modified or amended at any time by unanimous agreement of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article 9. Any such modification or amendment shall enter into force when the depositary Government has received notice from all such Contracting Parties that they have ratified it.

(b) Such modification or amendment shall thereafter enter into force as to any other Contracting Party when notice of ratification by it has been received by the depositary Government. Any such Contracting Party from which no notice of ratification is received within a period of two years from the date of entry into force of the modification or amendment in accordance with the provisions of sub-paragraph l(a) of this Article shall be deemed to have withdrawn from the present Treaty on the date of the expiration of such period.

2. (a) If after the expiration of thirty years from the date of entry into force of the present Treaty, any of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article 9 so requests by a communication addressed to the depositary Government, a Conference of all the Contracting Parties shall be held as soon as practicable to review the operation of the Treaty.

(b) Any modification or amendment to the present Treaty which is approved as such a Conference by a majority of the Contracting Parties there represented, including a majority of those whose representatives are entitle to participate in the meetings provided for under Article **9,** shall be communicated by the depositary Government to all the Contracting Parties immediately after the termination of the Conference and shall enter into force in accordance with the provisions of paragraph 1 of the present Article.

(c) If any such modification or amendment has not entered into force in accordance with the provisions of sub-paragraph l(a) of this Article within a period of two years after the date of its communication to all the Contracting Parties, any Contracting Party may at any time after the expiration of that period give notice to the depositary Government of its withdrawal from the present Treaty; and such withdrawal shall take effect two years after the receipt of the notice by the depositary Government.

Article 13

1. The present Treaty shall be subject to ratification by the signatory States. It shall be open for accession by arty State which is a Member of the United Nations, or by arty other State which may be invited to accede to the Treaty with the consent of all the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article 9 of the Treaty.

2. Ratification of or accession to the present Treaty shall be effected by each State in accordance with its constitutional processes.

3. Instruments of ratification and instruments of accession shall be deposited with the Government of the United States of America, hereby designated as the depositary Government.

4. The depositary Government shall inform all signatory and acceding States of the date of each deposit of any instrument of ratification or accession, and the date of entry into force of the Treaty and of any modification or amendment thereto.

5. Upon the deposit of instruments of ratification by all the signatory States, the present Treaty shall enter into force for those States and for States which have deposited instruments of accession. Thereafter the Treaty shall enter into force for any acceding State upon the deposit of its instrument of accession.

6. The present Treaty shall be registered by the depositary Government pursuant to Article 102 of the Charter of the United Nations.

Article 14

The present Treaty, done in the English, French, Russian and Spanish languages, each version being equally authentic, shall be deposited in the archives of the Government of the United States of America, which shall transmit duly certified copies thereof to the Governments of the signatory and acceding States.

Appendix D

The Convention on the Regulation of Antarctic Mineral Resource Activities

PREAMBLE

The **States** Parties to this Convention, hereinafter referred to as the Parties,

Recalling the provisions of the Antarctic Treaty;

Convinced that the Antarctic Treaty system has proved effective in promoting international harmony in furtherance of the purposes and principles of the Charter of the United Nations, in ensuring the absence of any measures of a military nature and the protection of the Antarctic environment and in promoting freedom of scientific research in Antarctica

Reaffirming that it is in the interest of all mankind that the Antarctic Treaty area shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord;

Noting the possibility that exploitable mineral resources may exist in Antarctica;

Bearing in mind the special legal and political status of Antarctica and the special responsibility of the Antarctic Treaty Consultative Parties to ensure that all activities in Antarctica are consistent with the purposes and principles of the Antarctic Treaty;

Bearing in mind also that a regime for Antarctic mineral resources must be consistent with Article IV of the Antarctic Treaty and in accordance therewith be without prejudice and acceptable to those States which assert rights of or claims to territorial sovereignty in Antarctica, and those States which neither recognize nor assert such rights or claims, including those States which assert a basis of claim to territorial sovereignty in Antarctica;

Noting the unique ecological, scientific and wilderness value of Antarctica and the importance of Antarctica to the global environment;

Recognizing that Antarctic mineral resource activities could adversely affect the Antarctic environment or dependent or associated ecosystems;

Believing that the protection of the Antarctic environment and dependent and associated ecosystems must be a basic consideration in decisions taken on possible Antarctic mineral resource activities;

Concerned to ensure that Antarctic mineral resource activities, should they occur, are compatible with scientific investigation in Antarctica and other legitimate uses of Antarctica;

Believing that a regime governing Antarctic mineral resource activities will further strengthen the Antarctic Treaty system;

Convinced that participation in Antarctic mineral resource **activities** should be open to all States which have an interest in such activities and *subscribe* to a regime governing them and that the special situation of develop ing country Parties to the regime should be taken into account;

Believing that the effective regulation of Antarctic mineral resource activities is in the interest of the international community as a whole;

HAVE AGREED as follows:

CHAPTER I: GENERAL PROVISIONS

Article 1

Definitions

For the purposes of this Convention:

1 "Antarctic Treaty" means the Antarctic Treaty done at Washington on 1 December 1959.

2 "Antarctic Treaty Consultative Parties" means the Contacting Parties to the Antarctic Treaty entitled to appoint representatives to participate in the meetings referred to in Article IX of that Treaty.

3 "Antarctic Treaty area" means the area to which the provisions of the Antarctic Treaty apply in accordance with Article VI of that Treaty.

4 "Convention for the Conservation of Antarctic Seals" means the Convention done at London on 1 June 1972,

5 "Convention on the Conservation of Antarctic Marine Living Resources means the Convention done at Canberra on 20 May 1980.

6 "Mineral resources" means all non-living natural non-renewable resources, including fossil fuels, metallic and non-metallic minerals.

7 "Antarctic mineral resource activities" means prospecting, exploration or development, but does not include scientific research activities within the meaning of Article III of the Antarctic Treaty.

8 "Prospecting" means activities, including logistic support aimed at identifying areas of mineral resource potential for possible exploration and development, including geological, geochemical and geophysical investigations and field observations, the use of remote sensing techniques and collection of surface, sea floor and sub-ice samples. Such activities do not include dredging

and excavations, except for the purpose of obtaining small-scale samples, or drilling, except shallow drilling into rock and sediment to depths not exceeding 25 meters or such other depth as the Commission may determine for particular circumstances.

9 "Exploration" means activities, including logistic support aimed at identifying and evaluating specific mineral resource occurrences or deposits, including exploratory drilling, dredging and other surface or subsurface excavations required to determine the nature and size of mineral resource deposits and the feasibility of their development but excluding pilot projects or commercial production.

10 'Development' means activities, including logistic support which take place following exploration and are aimed at or associated with exploitation of specific mineral resource deposits, including pilot projects, processing, storage and transport activities.

1 i "Operator" means:

(a) a Party; or
(b) an agency or instrumentality of a Party; or
(c) a juridical person established under the law of a Party; or
(d) a joint venture consisting exclusively of any combination of any of the foregoing,

which is undertaking Antarctic mineral resource activities and for which there is a Sponsoring State.

12 'Sponsoring State" means the Party with which an Operator has a substantial and genuine link, through being:

(a) in the case of a Party, that Party;
(b) in the case of an agency or instrumentality of a Party, that Party;
(c) in the case of a juridical person other than an agency or instrumentality of a Party, the Party:
  (i) under whose law that juridical person is established and to whose law it is subject, without prejudice to any other law which might be applicable, and
  (ii) in whose territory the management of that juridical person is located, and
  (iii) to whose effective control that juridical person is subject;
(d) in the case of a joint venture not constituting a juridical person:
  (i) where the managing member of the joint venture is a Party or an agency or instrumentality of a Party, that Party; or
  (ii) in any *other case, where* in relation to a Party the managing member of the joint venture satisfies the requirements of subparagraph (c) above, that Party.

13 "Managing member of the joint venture" means that member which the participating members in the joint venture have by agreement designated as having responsibility for central management of the joint venture, including the functions of organizing and supervising the activities to be undertaken, and controlling the financial resources involved.

14 "Effective control" means the ability of the Sponsoring State to ensure the availability of substantial resources of the Operator for purposes connected with the implementation of this Convention, through the location of such resources in the territory of the Sponsoring State or otherwise.

15 "Damage to the Antarctic environment or dependent or associated ecosystems' means any impact on the living or non-living components of that environment or those ecosystems, including harm to atmospheric, marine or terrestrial. life, beyond that which is negligible or which has been assessed and judged to be acceptable pursuant to this Convention.

16 "Commission" means the Antarctic Mineral Resources Commission established pursuant to Article 18.

17 "Regulatory Committee" means an Antarctic Mineral Resources Regulatory Committee established pursuant to Article 29.

18 "Advisory Committee" means the Scientific, Technical and Environmental Advisory Committee established pursuant to Article 23.

19 "Special Meeting of Parties" means the Meeting referred to in Article 28.

20 "Arbitral Tribunal" means an Arbitral Tribunal constituted as provided for in the Annex, which forms an integral part of this Convention.

Article 2

Objectives and General Principles

1 This Convention is an integral part of the Antarctic Treaty system, comprising the Antarctic Treaty, the measures in effect under that Treaty, and its associated separate legal instruments, the prime purpose of which is to ensure that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord. The Parties provide through this Convention, the principles it establishes, the rules it prescribes, the institutions it creates and the decisions adopted pursuant to it, a means for:

(a) assessing the possible impact on the environment of Antarctic mineral resource activities;
(b) determining whether Antarctic mineral resource activities are acceptable;
(c) goveming the conduct of such Antarctic mineral resource activities as may be found acceptable;

and

(d) ensuring that any Antarctic mineral resource activities are undertaken in strict conformity with this Convention.

2 In implementing this Convention, the Parties shall ensure that Antarctic mineral resource activities, should they occur, take place in a manner consistent with all the components of the Antarctic Treaty system and the obligations flowing therefrom.

3 In relation to Antarctic mineral resource activities, should they occur, the Parties acknowledge the special responsibility of the Antarctic Treaty Consultative Parties for the protection of the environment and the need to:

(a) protect the Antarctic environment and dependent and associated ecosystems;
(b) respect Antarctica's significance for, and influence on, the global environment;
(c) respect other legitimate uses of Antarctica;
(d) respect Antarctica's scientific value and aesthetic and wilderness qualities;
(e) ensure the safety of operations in Antarctica;
(f) promote opportunities for fair and effective participation of all Parties; and
(g) take into account the interests of the international community as a whole.

Article 3

Prohibition of Antarctic Mineral Resource Activities Outside this Convention

No Antarctic mineral resource activities shall be conducted except in accordance with this Convention and measures in effect pursuant to it and, in the case of exploration or development, with a Management Scheme approved pursuant to Article 48 or 54.

Article 4

Principles Concerning Judgments on Antarctic Mineral Resource Activities

1 Decisions about Antarctic mineral resource activities shall be based upon information adequate to enable informed judgments to be made about their possible impacts and no such activities shall take place unless this information is available for decisions relevant to those activities.

2 No Antarctic mineral resource activity shall take place until it is judged, based upon assessment of its possible impacts on the Antarctic environment and on dependent and on associated ecosystems, that the activity in question would not cause:

(a) significant adverse effects on air and water quality;
(b) significant changes in atmospheric, terrestrial or marine environments;
(c) significant changes in the distribution, abundance or productivity of populations of species of fauna or flora;
(d) further jeopardy to endangered or threatened species or populations of such species; or
(e) degradation of, or substantial risk to, areas of special biological, scientific, historic, aesthetic or wilderness significance.

3 No Antarctic mineral resource activity shall take place until it is judged, based upon assessment of its possible impacts, that the activity in question would not cause significant adverse effects on global or regional climate or weather patterns.

4 No Antarctic mineral resource activity shall take place until it is judged that:

(a) technology and procedures are available to provide for safe operations and compliance with paragraphs 2 and 3 above;
(b) there exists the capacity to monitor key environmental parameters and ecosystem components so as to identify any adverse effects of such activity and to provide for the modification of operating procedures as may be necessary in the light of the results of monitoring or increased knowledge of the Antarctic environment or dependent or associated ecosystems; and
(c) there exists the capacity to respond effectively to accidents, particularly those with potential environmental effects.

5 The judgments referred to in paragraphs 2, 3 and 4 above shall take into account the cumulative impacts of possible Antarctic mineral resource activities both by themselves and in combination with other such activities and other uses of Antarctica.

Article 5

Area of Application

1 This Convention shall, subject to paragraphs 2, 3 and 4 below, apply to the Antarctic Treaty area.

2 Without prejudice to the responsibilities of the Antarctic Treaty Consultative Parties under the Antarctic Treaty and measures pursuant to it, the Parties agree that this Convention shall regulate Antarctic mineral resource activities which take place on the continent of Antarctica and all Antarctic islands, including all ice shelves, south of 60° south latitude and in the seabed and subsoil *of* adjacent offshore areas up to the deep sea bed,

3 For the purposes of this Convention ''deep seabed" means the seabed and subsoil beyond the geographic

extent of the continental shelf as the term continental shelf is defined in accordance with international law.

4 Nothing in this Article shall be construed as limiting the application of other Articles of this Convention in so far as they relate to possible impacts outside the area referred to in paragraphs 1 and 2 above, including impacts on dependent or on associated ecosystems.

Article 6

Cooperation and International Participation

In the implementation of this Convention cooperation within its framework shall be promoted and encouragement given to international participation in Antarctic mineral resource activities by interested Parties which are Antarctic Treaty Consultative Parties and by other interested Parties, in particular, developing countries in either category. Such participation may be realized through the Parties themselves and their Operators.

Article 7

Compliance with this Convention

1 Each Party shall take appropriate measures within its competence to ensure compliance with this Convention and any measures in effect pursuant to it.

2 If a Party is prevented by the exercise of jurisdiction by another Party from ensuring compliance in accordance with paragraph 1 above, it shall not to the extent that it is so prevented, bear responsibility for that failure to ensure compliance.

3 If any jurisdictional dispute related to compliance with this Convention or any measure in effect pursuant to it arises between two or more Parties, the Parties concerned shall immediately consult together with a view to reaching a mutually acceptable solution.

4 Each Party shall notify the Executive Secretary, for circulation to all other Parties, of the measures taken pursuant to paragraph 1 above.

5 Each Party shall exert appropriate efforts, consistent with the Charter of the United Nations, to the end that no one engages in any Antarctic mineral resource activities contrary to the objectives and principles of this Convention.

6 Each Party may, whenever it deems it necessary, draw the attention of the Commission to any activity which in its opinion affects the implementation of the objectives and principles of this Convention.

7 The Commission shall draw the attention of all Parties to any activity which, in the opinion of the Commission, affects the implementation of the objectives and principles of this Convention or the compliance by any Party with its obligations under this Convention and any measures in effect pursuant to it.

8 The Commission shall draw the attention of any State which is not a Party to this Convention to any activity undertaken by that State, its agencies or instrumentalities, natural or juridical persons, ships, aircraft or other means of transportation which, in the opinion of the Commission, affects the implementation of the objectives and principles of this Convention. The Commission shall inform all Parties accordingly.

9 Nothing in this Article shall affect the operation of Article 12(7) of this Convention or Article VIII of the Antarctic Treaty.

Article 8

Response Action and Liability

1 An Operator undertaking any Antarctic mineral resource activity shall take necessary and timely response action, including prevention, containment, clean up and removal measures, if the activity results in or threatens to result in damage to the Antarctic environment or dependent or associated ecosystems. The Operator, through its Sponsoring State, shall ***notify the*** Executive Secretary, for circulation to the relevant institutions of this Convention and to all Parties, of action taken pursuant to this paragraph.

2 An Operator shall be strictly liable for:

(a) damage to the Antarctic environment or dependent or associated ecosystems arising from its Antarctic mineral resource activities, including payment in the event that there has been no restoration to the *status quo ante;*

(b) loss of or impairment to an established use, as referred to in Article 15, or loss of or impairment to an established use of dependent or associated ecosystems, arising directly out of damage described in subparagraph (a) above;

(c) loss of or damage to property of a third party or loss of life or personal injury of a third party arising directly out of damage described in subparagraph (a) above; and

(d) reimbursement of reasonable costs by whomsoever incurred relating to necessary response action, including prevention, containment, clean up and removal measures, and action taken to restore the *status quo ante* where Antarctic mineral resource activities undertaken by that Operator result in or threaten to result in damage to the Antarctic environment or dependent or associated ecosystems.

3 (a) Damage of the kind referred to in paragraph 2 above which would not have occurred or continued if the Sponsoring State had carried out its obligations under this Convention with respect to its Operator shall, in accordance with international law, entail liability of that

Sponsoring State. Such liability shall be limited to that portion of liability not **satisfied** by the Operator or otherwise,

(b) Nothing in subparagraph (a) above shall affect the application of the rules of international law applicable in the event that damage not referred to in that subparagraph would not have occurred or continued if the Sponsoring State had carried out its obligations under this Convention with respect to its Operator.

4 An Operator shall not be liable pursuant to paragraph 2 above if it proves that the damage has been caused directly by, and to the extent that it has been caused directly by:

(a) an event constituting in the circumstances of Antarctica a natural disaster of an exceptional character which could not reasonably have been foreseen; or

(b) armed conflict, should it occur notwithstanding the *Antarctic* Treaty, or an act of terrorism directed against the activities of the Operator, against which no reasonable precautionary measures could have been effective.

5 Liability of an Operator for any loss of life, personal injury or loss of or damage to property other than that governed by this Article shall be regulated by applicable law and procedures.

6 If an Operator proves that damage has been caused totally or in part by an intentional or grossly negligent act or omission of the party seeking redress, that Operator may be relieved totally or in part from its obligation to pay compensation in respect of the damage suffered by such party.

7 (a) Further rules and procedures in respect of the provisions on liability set out in this Article shall be elaborated through a separate Protocol which shall be adopted by consensus by the members of the Commission and shall enter into force according to the procedure provided for in Article 62 for the entry into force of this Convention.

(b) Such rules and procedures shall be designed to enhance the protection of the Antarctic environment and dependent and associated ecosystems.

(c) Such rules and procedures:

(i) may contain provisions for appropriate limits on liability, where such limits can be justified;

(ii) without prejudice to Article 57, shall prescribe means and mechanisms such as a claims tribunal or other form by which claims against Operators pursuant to this Article may be assessed and adjudicated;

(iii) shall ensure that a means is provided to assist with immediate response action, and to satisfy liability under paragraph 2 above in the event *inter alia*, that an Operator liable is financially incapable of meeting its obligation in full, that it exceeds any relevant limits of liability, that there is a defense to liability or that the loss or damage is of undetermined origin. Unless it is determined during the elaboration of the Protocol that there are other effective means of meeting these objectives, the Protocol shall establish a Fund or Funds and make provision in respect of such Fund or Funds, *inter alia*, for the following:

—financing by Operators or on industry wide bases;

--ensuring the permanent liquidity and mandatory supplementation thereof in the event of insufficiency;

-reimbursement of costs of response action, by whomsoever incurred.

8 Nothing in paragraphs 4, 6 and 7 above or in the Protocol adopted pursuant to paragraph 7 shall affect in any way the provisions of paragraph 1 above.

9 No application for an exploration or development permit shall be made until the Protocol provided for in paragraph 7 above is in force for the Party lodging such application.

10 Each Party, pending the entry into force for it of the Protocol provided for in paragraph 7 above, shall ensure, consistently with Article *7* and in accordance with its legal system, that recourse is available in its national courts for adjudicating liability claims pursuant to paragraphs 2, 4 and 6 above against Operators which are engaged in prospecting. Such recourse shall include the adjudication of claims against any Operator it has sponsored. Each Party shall also ensure, in accordance with its legal system, that the Commission has the right to appear as a party in its national courts to pursue relevant liability claims under paragraph 2(a) above.

11 Nothing in this Article or in the Protocol provided for in paragraph 7 above shall be construed so as to:

(a) preclude the application of existing rules on liability, and the development in accordance with international law of further such rules, which may have application to either States or Operators; or

(b) affect the right of an Operator incurring liability pursuant to this Article to seek redress from another party which caused or contributed to the damage in question.

12 When compensation has been paid other than under this Convention liability under this Convention shall be offset by the amount of such payment.

Article 9

Protection of Legal Positions under the Antarctic Treaty

Nothing in this Convention and no acts or activities taking place while this Convention is in force shall:

(a) constitute a basis for asserting, supporting or denying a claim to territorial sovereignty in the Antarctic Treaty area or create any rights of sovereignty in the Antarctic Treaty area;

(b) be interpreted as a renunciation or diminution by any Party of, or as prejudicing, any right or claim or basis of claim to territorial sovereignty in Antarctica or to exercise coastal state jurisdiction under international law;

(c) be interpreted as prejudicing the position of any Party as regards its recognition or non-recognition of any such right, claim or basis of claim; or

(d) affect the provision of Article IV(2) of the Antarctic Treaty that no new claim, or enlargement of an existing claim, to territorial sovereignty in Antarctica shall be asserted while the Antarctic Treaty is in force.

Article 10

Consistency with the Other Components of the Antarctic Treaty System

1 Each Party shall ensure that Antarctic mineral resource activities take place in a manner consistent with the components of the Antarctic Treaty system, including the Antarctic Treaty, the Convention for the Conservation of Antarctic Seals and the Convention on the Conservation of Antarctic Marine Living Resources and the measures in effect pursuant to those instruments.

2 The Commission shall consult and cooperate with the Antarctic Treaty Consultative Parties, the Contracting Parties to the Convention for the Conservation of Antarctic Seals, and the Commission for the Conservation of Antarctic Marine Living Resources with a view to ensuring the achievement of the objectives and principles of this Convention and avoiding any interference with the achievement of the objectives and principles of the Antarctic Treaty, the Convention for the Conservation of Antarctic Seals or the Convention on the Conservation of Antarctic Marine Living Resources, or inconsistency between the measures in effect pursuant to those instruments, and measures in effect pursuant to this Convention.

Article 11

Inspection under the Antarctic Treaty

All stations, installations and equipment, in the Antarctic Treaty area, relating to Antarctic mineral resource activities, as well as ships and aircraft supporting such activities at points of discharging or embarking cargoes or personnel at such stations and installations, shall be open at all times to inspection by observers designated under Article VII of the Antarctic Treaty for the purposes of that Treaty.

Article 12

Inspection under this Convention

1 In order to promote the objectives and principles and to ensure the observance of this Convention and measures in effect pursuant to it, all stations, installations and equipment relating to Antarctic mineral resource activities in the area in which these activities are regulated by this Convention, as well as ships and aircraft supporting such activities at points of discharging or embarking cargoes or personnel anywhere in that area shall be open at all times to inspection by:

(a) observers designated by any member of the Commission who shall be nationals of that member; and

(b) observers designated by the Commission or relevant Regulatory Committees.

2 Aerial inspection maybe carried out at any time over the area in which Antarctic mineral resource activities are regulated by this Convention.

3 The Commission shall maintain an up-to-date list of observers designated pursuant to paragraph l(a) and (b) above.

4 Reports from the observers shall be transmitted to the Commission and to any Regulatory Committee having competence in the area where the inspection has been carried out.

5 Observers shall avoid interference with the safe and normal operations of stations, installations and equipment visited and shall respect measures adopted by the Commission to protect confidentiality of data and information.

6 Inspections undertaken pursuant to paragraph l(a) and (b) above shall be compatible and reinforce each other and shall not impose an undue burden on the operation of stations, installations and equipment visited,

7 In order to facilitate the exercise of their functions under this Convention, and without prejudice to the respective positions of the Parties relating to jurisdiction over all other persons in the area in which Antarctic mineral resource activities are regulated by this Conven-

tion, observers designated under this Article shall be subject only to the jurisdiction of the Party of which they are nationals in respect of all acts or omissions occurring while they are in that area for the purpose of exercising their functions.

8 No exploration or development shall take place in an area identified pursuant to Article 41 until effective provision has been made for inspection in that area.

Article 13

Protected Areas

1 Antarctic mineral resource activities shall be prohibited in any area designated as a Specially Protected Area or a Site of Special Scientific Interest under Article IX (1) of the Antarctic Treaty. Such activities shall also be prohibited in any other area designated as a protected area in accordance with Article IX(1) of the Antarctic Treaty, except to the extent that the relevant measure provides otherwise. Pending any designation becoming effective in accordance with Article IX(4) of the Antarctic Treaty, no Antarctic mineral resource activities shall take place in any such area which would prejudice the purpose for which it was designated.

2 The Commission shall also prohibit or restrict Antarctic mineral resource activities in any area which, for historic, ecological, environmental, scientific or other reasons, it has designated as a protected area.

3 In exercising its powers under paragraph 2 above or under Article 41 the Commission shall consider whether to restrict or prohibit Antarctic mineral resource activities in any area, in addition to those referred to in paragraph 1 above, protected or set aside pursuant to provisions of other components of the Antarctic Treaty system, to ensure the purposes for which they are designated.

4 In relation to any area in which Antarctic mineral resource activities are prohibited or restricted in accordance with paragraph 1, 2 or 3 above, the Commission shall consider whether, for the purposes of Article 4 (2) (e) it would be prudent, additionally, to prohibit or restrict Antarctic mineral resource activities in adjacent areas for the purpose of creating a buffer zone.

5 The Commission shall give effect to Article 10(2) in acting pursuant to paragraphs 2, 3 and 4 above.

6 The Commission shall, where appropriate, bring any decisions it takes pursuant to this Article to the attention of the Antarctic Treaty Consultative Parties, the Contracting Parties to the Convention for the Conservation of Antarctic Seals, the Commission for the Conservation of Antarctic Marine Living Resources and the Scientific Committee on Antarctic Research.

Aticle 14

Non-Discrimination

In the implementation of this Convention there shall be no discrimination against any Party or its Operators,

Article 15

Respect for Other Uses of Antarctica

1 Decisions about Antarctic mineral resource activities shall take into account the need to respect other established uses of Antarctica, including:

(a) the operation of stations and their associated installations, support facilities and equipment in Antarctica;
(b) scientific investigation in Antarctica and cooperation therein;
(c) the conservation, including rational use, of Antarctic marine living resources;
(d) tourism;
(e) the preservation of historic monuments; and
(f) navigation and aviation,

that are consistent with the Antarctic Treaty system.

2 Antarctic mineral resource activities shall be conducted so as to respect any uses of Antarctica as referred to in paragraph 1 above.

Article 16

Availability and Confidentiality of Data and Information

Data and information obtained from Antarctic mineral resource activities shall, to the greatest extent practicable and feasible, be made freely available, provided that:

(a) as regards data and information of commercial value deriving from prospecting, they may be retained by the Operator in accordance with Article 37;
(b) as regards data and information deriving from exploration or development the Commission shall adopt measures relating, as appropriate, to their release and to ensure the confidentiality of data and information of commercial value.

Article 17

Notifications and Provisional Exercise of Functions of the Executive Secretary

1 Where in this Convention there is a reference to the provision of information, a notification or a report to any institution provided for in this Convention and that institution has not been established, the information, notification or report shall be provided to the Executive Secretary who shall circulate it as required.

2 Where in this Convention a function is assigned to the Executive Secretary and no Executive Secretary has been appointed under Article 33, that function shall be performed by the Depositary.

CHAPTER II: INSTITUTIONS

Article 18

Commission

1 There is hereby established the Antarctic Mineral Resources Commission.

2 Membership of the Commission shall be as follows:

(a) each Party which was an Antarctic Treaty Consultative Party on the date when this Convention was opened for signature; and

(b) each other Party during such time as it is actively engaged in substantial scientific, technical or environmental research in the area to which this Convention applies directly relevant to decisions about Antarctic mineral resource activities, particularly the assessments and judgments called for in Article 4; and

(c) each other Party sponsoring Antarctic mineral resource exploration or development during such time as the relevant Management Scheme is in force.

3 A Party seeking to participate in the work of the Commission pursuant to subparagraph (b) or (c) above shall notify the Depositary of the basis upon which it seeks to become a member of the Commission. In the case of a Party which is not an Antarctic Treaty Consultative Party, such notification shall include a declaration of intent to abide by recommendations pursuant to Article IX(1) of the Antarctic Treaty. The Depositary shall communicate to each member of the Commission such notification and accompanying information.

4 The Commission shall consider the notification at its next meeting. In the event that a Party referred to in paragraph 2(b) above submitting a notification pursuant to paragraph 3 above is an Antarctic Treaty Consultative Party, it shall be deemed to have satisfied the requirements for Commission membership unless more than one-third of the members of the Commission object at the meeting at which such notification is considered. Any other Party submitting a notification shall be deemed to have satisfied the requirements for Commission membership if no member of the Commission objects at the meeting at which such notification is considered.

5 Each member of the Commission shall be represented by one representative who maybe accompanied by alternate representatives and advisers.

6 Observer status in the Commission shall be open to any Party and to any Contracting Party to the Antarctic Treaty which is not a Party to this Convention.

Aticle 19

Commission Meets

1 (a) The first meeting of the Commission, held for the purpose of taking organizational, financial and other decisions necessary for the effective functioning of this Convention and Its institutions, shall be convened within six months of the entry into force of this Convention.

(b) After the Commission has held the meeting or meetings necessary to take the decisions referred to in subparagraph (a) above, the Commission shall not hold further meetings except in accordance with paragraph 2 or 3 below.

2 Meetings of the Commission shall be held within two months of:

(a) receipt of a notification pursuant to Article 39;

(b) a request by at least six members of the Commission; or

(c) a request by a member of a Regulatory Committee in accordance with Article 49(l).

3 The Commission may establish a regular schedule of meetings if it determines that it is necessary for the effective functioning of this Convention.

4 Unless the Commission decides otherwise, its meetings shall be convened by the Executive Secretary.

Article 20

Commission Procedure

1 The Commission shall elect from among its members a Chairman and two Vice-Chairmen, each of whom shall be a representative of a different Party,

2 (a) Until such time as the Commission has established a regular schedule of meetings in accordance with Article 19(3), the Chairman and Vice-Chairmen shall be elected to serve for a period of two years, provided that if no meeting is held during that period they shall continue to serve until the conclusion ofthe meetingheld thereafter.

(b) When a regular schedule of meetings has been established, the Chairman and Vice-Chairmen shall be elected to serve for a period of two years.

3 The Commission shall adopt its rules of procedure. Such rules may include provisions concerning the number of terms of office which the Chairman and Vice-Chairmen may serve and for the rotation of such offices.

4 The Commission may establish such subsidiary bodies as are necessary for the performance of its

functions.

5 The Commission may decide to establish a permanent headquarters which shall be in New Zealand.

6 The Commission shall have legal personality and shall enjoy in the territory of each Party such legal capacity as may be necessary to perform its functions and achieve the objectives of this Convention.

7 The privileges and immunities to be enjoyed by the Commission, the Secretariat and representatives attending meetings in the territory of a Party shall be determined by agreement between the Commission and the Party concerned.

Article 21

Functions of the Commission

1 Functions of the Commission shall be:

(a) to facilitate and promote the collection and exchange of scientific, technical and other information and research projects necessary to predict, detect and assess the possible environmental impact of Antarctic mineral resource activities, including the monitoring of key environmental parameters and ecosystem components;

(b) to designate areas in which Antarctic mineral resource activities shall be prohibited or restricted in accordance with Article 13, and to perform the related functions assigned to it in that Article;

(c) to adopt measures for the protection of the Antarctic environment and dependent and associated ecosystems and for the promotion of safe and effective exploration and development techniques and, as it may deem appropriate, to make available a handbook of such measures;

(d) to determine, in accordance with Article 41, whether or not to identify an area for possible exploration and development, and to perform the related functions assigned to it in Article 42;

(e) to adopt measures relating to prospecting applicable to all relevant Operators:

(i) to determine for particular circumstances maximum drilling depths in accordance with article 1(8);

(ii) to restrict or prohibit prospecting consistently with Articles 13, 37 and 38;

(9 to ensure the effective application of Articles 12(4), 37(7) and (8), 38(2) and 39(2), which require the submission to the Commission of information, notifications and reports;

(g) to give advance public notice of matters upon which it is requesting the advice of the Advisory Committee;

(h) to adopt measures relating to the availability and confidentiality of data and information, including measures pursuant to Article 16;

(i) to elaborate the principle of non-discrimination set forth in Article 14;

(j) to adopt measures with respect to maximum block sizes;

(k) to perform the functions assigned to it in Article 29;

(1) to review action by Regulatory Committees in accordance with Article 49;

(m) to adopt measures in accordance with Articles 6 and 41(l)(d) related to the promotion of cooperation and to participation in Antarctic mineral resource activities;

(n) to adopt general measures pursuant to Article 51(6);

(o) to take decisions on budgetary matters and adopt financial regulations in accordance with Article 35;

(p) to adopt measures regarding fees payable in connection with notifications submitted pursuant to Articles 37 and 39 and applications lodged pursuant to Articles 44 and 53, the purpose of which fees shall be to cover the administrative costs of handling such notifications and applications;

(q) to adopt measures regarding levies payable by Operators engaged in exploration and development, the principal purpose of which levies shall be to cover the costs of the institutions of this Convention;

(r) to determine in accordance with Article 35(7) the disposition of revenues, if any, accruing to the Commission which are surplus to the requirements for financing the budget pursuant to Article 35;

(s) to perform the functions assigned to it in Article 7(7) and (8);

(t) to perform the functions relating to inspection assigned to it in Article 12;

(u) to consider monitoring reports received pursuant to Article 52;

(v) to perform the functions relating to dispute settlement assigned to it in Article 59;

(w) to perform the functions relating to consultation and cooperation assigned to it in Articles 10(2) and 34;

a(X) to keep under review the conduct of Antarctic mineral resource activities with a view to safeguarding the protection of the Antarctic environment in the interest of all mankind; and

(y) to perform such other functions as are provided for elsewhere in this Convention.

2 In performing its functions the Commission shall seek and take full account of the views of the Advisory Committee provided in accordance with article 26.

3 Each measure adopted by the Commission shall specify the date on which it comes into effect.

4 The Commission shall, subject to Article 16 and measures in effect pursuant to it and paragraph l(h) above, ensure that a publicly available record of its meetings and decisions and of information, notifications and reports submitted to it is maintained.

Article 22

Decision Making in the Commission

1 The Commission shall take decisions on matters of substance by a three-quarters majority of the members present and voting. When a question arises as to whether a matter is one of substance or not, that matter shall be treated as one of substance unless otherwise decided by a three-quarters majority of the members present and voting.

2 Notwithstanding paragraph 1 above, consensus shall be required for the following:

(a) the adoption of the budget and decisions on budgetary and related matters pursuant to Article 21 (1) (p), (q) and (r) and Article 35(l), (2), (3), (4) and (5);

(b) decisions taken pursuant to Article 21 (1) (i)

(c) decisions taken pursuant to Article 41(2).

3 Decisions on matters of procedure shall be taken by a simple majority of the members present and voting.

4 Nothing in this Article shall be interpreted as preventing the Commission, in taking decisions on matters of **substance,** from endeavoring to reach a consensus.

5 For the purposes of this Article, consensus means the absence of a formal objection. If, with respect to any decision covered by paragraph 2(c) above, the Chairman of the Commission determines that there would be such an objection he shall consult the members of the Commission. If, as a result of these consultations, the Chairman determines that an objection would remain, he shall convene those members most directly interested for the purpose of seeking to reconcile the differences and producing a generally acceptable proposal.

Article *23*

Advisory Committee

1 There is hereby established the Scientific, Technical and Environmental Advisory Committee.

2 Membership of the Advisory Committee shall be open to all Parties.

3 Each member of the Advisory Committee shall be represented by one representative with suitable scientific, technical or environmental competence who may be accompanied by alternate representatives and by experts and advisers.

4 Observer status in the Advisory Committee shall be open to any Contracting Party to the Antarctic Treaty or to the Convention on the Conservation of Antarctic Marine Living Resources which is not a Party to the Convention.

Article 24

Advisory Committee Meetings

1 Unless the Commission decides otherwise, the Advisory Committee shall be convened for its first meeting within six months of the first meeting of the Commission. It shall meet thereafter as necessary to fulfill its functions on the basis of a schedule established by the Commission.

2 Meetings of the Advisory Committee, in addition to those scheduled pursuant to paragraph 1 above, shall be convened at the request of at least six members of the Commission or pursuant to Article 40(1).

3 Unless the Commission decides otherwise, the meetings of the Advisory Committee shall be convened by the Executive Secretary.

Article 25

Advisory Committee Procedure

1 The Advisory Committee shall elect from among its members a Chairman and two Vice-Chairmen, each of whom shall be representative of a different Party.

2 (a) Until such time as the Commission has established a schedule of meetings in accordance with Article **24(l),** the Chairman and Vice-Chairmen shall be elected to serve for a period of two years, provided that if no meeting is held during that period they shall continue to seine until the conclusion of the first meeting held thereafter,

(b) When a schedule of meetings has been established, the Chairman and Vice-Chairmen shall be elected to serve for a period of two years.

3 The Advisory Committee shall give advance public notice of its meetings and of matters to be considered at each meeting so as to permit the receipt and consideration of views on such matters from international organizations having an interest in them. For this purpose the Advisory Committee may, subject to review by the Commission, establish procedures for the transmission of relevant information to these organizations.

4 The Advisory Committee shall, by a two-thirds majority of the members present and voting, adopt its

rules of procedure. Such rules may include provisions concerning the number of terms of office which the Chairman and Vice-Chairmen may serve and for the rotation of such offices. The rules of procedure and any amendments thereto shall be subject to approval by the Commission.

5 The Advisory Committee may establish such subcommittees, subject to budgetary approval, as may be necessary for the performance of its functions.

Article 26

Functions of the Advisory Committee

1 The *Advisory* Committee shall advise the Commission and Regulatory Committees, as required by this Convention, or as requested by them, on the scientific, technical and environmental aspects of Antarctic mineral resource activities. It shall provide a forum for consultation and cooperation concerning the collection, exchange and evaluation of information related to the scientific, technical and environmental aspects of Antarctic mineral resource activities.

2 It shall provide advice to:

(a) the Commission relating to its functions under Articles 21(1) (a) to (f), (u) and (x) and 35(7) (a) (in matters relating to scientific research) as well as on the implementation of Article **4;** and

(b) Regulatory Committees with respect to:

(i) the implementation of Article 4;

(ii) scientific, technical and environmental aspects of Articles 43(3) and (5), 45,47,51, 52 and 54;

(iii) data to be collected and reported in accordance with Articles *47* and 52; and

(iv) the scientific, technical and environmental implications of reports and reported data provided in accordance with Articles 47 and 52.

3 It shall provide advice to the Commission and to Regulatory Committees on:

(a) criteria in respect of the judgments required under Article *4(2)* and (3) for the purposes of Article 4(l);

(b) types of data and information required to carry out its functions, and how they should be collected, reported and archived;

(c) scientific research which would contribute to the base of data and information required in subparagraph (b) above;

(d) effective procedures and systems for data and information analysis, evaluation, presentation and dissemination to facilitate the judgments referred to in Article 4; and

(e) possibilities for scientific, technical and environmental cooperation amongst interested Parties which are developing countries and other Parties.

4 The Advisory Committee, in providing advice on decisions to be taken in accordance with Articles 41,43, 45 and 54 shall, in each case, undertake a comprehensive environmental and technical assessment of the proposed actions. Such assessments shall be based on all information, and any amplifications thereof, available to the Advisory Committee, including the information provide pursuant to Articles 39(2)(e), 44(2) (b)(iii) and 53(2)(b). The assessments of the Advisory Committee shall, in each case, address the nature and scope of the decisions to be taken and shall include consideration, as appropriate, of, *inter alia:*

(a) the **adequacy** of existing information to enable informed judgments to be made;

(b) the nature, extent, duration and intensity of likely direct environmental impacts resulting from the proposed activity;

(c) possible indirect impacts;

(d) means and alternatives by which such direct or indirect impacts might be reduced, including environmental consequences of the alternative of not proceeding;

(e) cumulative impacts of the proposed activity in the light of existing or planned activities;

(f) capacity to respond effectively to accidents with potential environmental effects;

(g) the environmental significance of unavoidable impacts; and

(h) the probabilities of accidents and their environmental consequences.

5 In preparing its advice the Advisory Committee may seek information and advice from other scientists and experts or scientific organizations as may be required on an ad *hoc* basis.

6 The Advisory Committee shall, with a view to promoting international participation in Antarctic mineral resource activities as provided for in Article 6, provide advice concerning the availability to interested developing country Parties and other Parties, of the information referred to in paragraph 3 above, of training programs related to scientific, technical and environmental matters bearing on Antarctic mineral resource activities, and of opportunities for cooperation among Parties in these programs.

Article 27

Reporting by the Advisory Committee

The Advisory Committee shall present a report on each of its meetings to the Commission and to any relevant

Regulatory Committee. The report shall cover all matters considered at the meeting and shall reflect the conclusions reached and all the views expressed by members of the Advisory Committee. The report shall be circulated by the Executive Secretary to all Parties, and to observers attending the meeting, and shall thereupon be made publicly available.

Article 28

Special Meeting of Parties

1 A Special Meeting of Parties shall, as required, be convened in accordance with Article 40(2) and shall have the functions, in relation to the identification of an area for possible exploration and development specified in Article 40(3).

2 Membership of a Special Meeting of Parties shall be open to all Parties, each of which shall be represented by one representative who may be accompanied by alternate representatives and advisers.

3 Observer status at a Special Meeting of Parties shall be open to any Contracting Party to the Antarctic Treaty which is not a Party to this Convention.

4 Each Special Meeting of Parties shall elect from among its members a Chairman and Vice-Chairman, each of whom shall serve for the duration of that meeting. The Chairman and Vice-Chairman shall not be representatives of the same Party.

5 The Special Meeting of Parties shall, by a two-thirds majority of the members present and voting, adopt its rules of procedure. Until **such time as** this has been done the Special Meeting of Parties shall apply provisional rules of procedure drawn up by the Commission.

6 Unless the Commission decides otherwise, a Special Meeting of Parties shall be convened by the Executive Secretary and shall be held at the same venue as the meeting of the Commission convened to consider the identification of an area for possible exploration and development.

Article 29

Regulatory Committees

1 An Antarctic Mineral Resources Regulatory Committee shall be established for each area identified by the Commission pursuant to Article 41.

2 Subject to paragraph 6 below, each Regulatory Committee shall consist of 10 members. Membership shall be determined by the Commission in accordance with this Article and, taking into account Article 9, shall include:

(a) the member, if any, or if there are more than one, those members of the Commission identified by reference to Article 9(b) which assert rights or claims in the identified area;

(b) the two members of the Commission also identified by reference to Article 9(b) which assert a basis of claim in Antarctic

(c) other members of the Commission determined in accordance with this Article so that the Regulatory Committee shall, subject to paragraph 6 below, consist, in total, of 10 members:
   (i) four members identified by reference to Article 9(b) which assert rights or claims, including the member or members, if any, referred to in subparagraph (a) above; and
   (ii) six members which do not assert rights or claims as described in Article 9(b), including the two members referred to in subparagraph (b) above.

3 Upon the identification of an area in accordance with Article 41(2), the Chairman of the Commission shall, as soon as possible and in any event within 90 days, make a recommendation to the Commission concerning the membership of the Regulatory Committee. To this end the Chairman shall consult, as appropriate, with the Chairman of the Advisory Committee and all members of the Commission. Such recommendation shall comply with the requirements of paragraphs 2 and 4 of this Article and shall ensure:

(a) the inclusion of members of the Commission which, whether through prospecting, scientific research or otherwise, have contributed substantial scientific, technical or environmental information relevant to the identification of the area by the Commission pursuant to Article 41;

(b) adequate and equitable repmsentation of developing country members of the Commission, having regard to the overall balance between developed and developing country members of the Commission, including at least three developing country members of the Commission;

(c) that account is taken of the value of a rotation of membership of Regulatory Committees as a further means of ensuring equitable representation of members of the Commission.

4 (a) When there are one or more members of the Regulatory Committee referred to in paragraph 2(a) above, the Chairman of the Commission shall make the recommendation in respect of paragraph 2(c) (i) above upon the nomination, if any, of such member or members which shall take into account paragraph 3 above, in particular subparagraph (b) of that paragraph.

(b) In making the recommendation in respect of paragraph 2(c) (ii) above, the Chairman of the Commission shall give full weight to the views (which shall take into account paragraph 3 above) which may be presented on behalf of those members of the Commission which do not assert rights of or claims to territorial sovereignty in Antarctica and, with reference to the requirements of paragraph 3(b) above, to the views which may be presented on behalf of the developing countries among them.

5 The recommendation of the Chairman of the Commission shall be deemed to have been approved by the Commission if it does not decide otherwise at the same meeting as the recommendation is submitted. In taking any decision in accordance with this Article the Commission shall ensure that the requirements of paragraphs 2 and 3 above are complied with and that the nomination, if any, referred to in paragraph 4(a) above is given effect.

6 (a) If a member of the Commission which has sponsored prospecting in the identified area and submitted the notification pursuant to Article 39 upon which the Commission based its identification of the area pursuant to Article 41, is not a member of the Regulatory Committee by virtue of paragraphs 2 and 3 above, that member of the Commission shall be a member of the Regulatory Committee until such time as an application for an exploration permit is lodged pursuant to Article 44.

(b) If a Party lodging an application for an exploration permit pursuant to Article 44 is not a member of the Regulatory Committee by virtue of paragraphs 2 and 3 above, that Party shall be a member of the Regulatory Committee for its consideration of that application. Should such application result in approval of a Management Scheme pursuant to Article 48, the Party in question shall remain a member of the Regulatory Committee during such time as that Management Scheme is in force with the right to take part in decisions on matters affecting that Management Scheme.

7 Nothing in this Article shall be interpreted as affecting Article IV of the Antarctic Treaty.

Article 30

Regulatory Committee Procedure

1 The first meeting of each Regulatory Committee shall be convened by the Executive Secretary in accordance with Article 43 (1) Each Regulatory Committee shall meet thereafter when and where necessary to fulfill its functions.

2 Each member of a Regulatory Committee shall be represented by one representative who may be accompanied by alternate representatives and advisers,

3 Each Regulatory Committee shall elect from among its members a Chairman and Vice-Chairman. The Chairman and Vice-Chairman shall not be representatives of the same Party.

4 Any Party may attend meetings of a Regulatory Committee as an observer.

5 Each Regulatory Committee shall adopt its rules of procedure. Such rules may include provisions concerning the period and number of terms of office which the Chairman and Vice-Chairman may serve and for the rotation of such offices.

Article 31

Functions of Regulatory Committees

1 The functions of each Regulatory Committee shall be:

(a) to undertake the preparatory work provided for in Article 43;
(b) to consider applications for exploration and development permits in accordance with Articles 45, 46 and 54;
(c) to approve Management Schemes and issue exploration and development permits in accordance with Articles 47,48 and 54;
(d) to monitor exploration and development activities in accordance with Article 52;
(e) to perform the functions assigned to it in Article 51;
(f) to perform the functions relating to inspection assigned to it in Article 12;
(g) to perform the functions relating to dispute settlement assigned to it in Article 47(r); and
(h) to perform such other functions as are provided for elsewhere in this Convention.

2 In performing its functions each Regulatory Committee shall seek and take full account of the views of the Advisory Committee provided in accordance with Article 26.

3 Each Regulatory Committee shall, subject to Article 16 and measures in effect pursuant to it and Article 21 (1) (h), ensure that a publicly available record of its decisions, and of Management Schemes in force, is maintained.

Article 32

Decision Making in Regulatory Committees

1 Decisions by a Regulatory Committee pursuant to Articles 48 and 54(5) shall be taken by a two-thirds majority of the members present and voting, which majority shall include a simple majority of those members present and voting referred to in Article 29(2) (c) (i) and also a simple majority of those members present and voting referred to in Article 29(2) (c) (ii)

2 Decisions by a Regulatory Committee pursuant to Article 43(3) and (5) shall be taken by a two-thirds majority of the members present and voting, which majority shall include at least half of those members present and voting referred to in Article 29(2) (c) (i) and also at least half of those members present and ***voting*** referred to in Article 29(2) (c) (ii)

3 Decisions on all other matters of substance shall be taken by a two-thirds majority of the members present and voting. When a question arises as to whether a matter is one of substance or not, that matter shall be treated as one of substance unless otherwise decided by a two-thirds majority of the members present and voting.

4 Decisions on matters of procedure shall be taken by a simple majority of the members present and voting.

5 Nothing in this Article shall be interpreted as preventing a Regulatory Committee, in taking decisions on matters of substance, from endeavoring to reach a consensus.

Article 33

Secretariat

1 The Commission may establish a Secretariat to serve the Commission, Regulatory Committees, the Advisory Committee, the Special Meeting of Parties and any subsidiary bodies established.

2 The Commission may appoint an Executive Secretary, who shall be the head of the Secretariat, according to such procedures and on such terms and conditions as the Commission may determine. The Executive Secretary shall serve for a four year term and may be reappointed.

3 The Commission may, with due regard to the need for efficiency and economy, authorize such staff establishment for the Secretariat as may be necessary. The Executive Secretary shall appoint, direct and supervise the staff according to such rules and procedures and on such terms and conditions as the Commission may determine.

4 The Secretariat shall perform the functions specified in this Convention and, subject to the approved budget, the tasks entrusted to it by the Commission, Regulatory Committees, the Advisory Committee and the Special Meeting of Parties.

Article 34

Cooperation with International Organizations

1 The Commission and, as appropriate, the Advisory Committee shall cooperate with the Antarctic Treaty Consultative Parties, the Contracting Parties to the Convention for the Conservation of Antarctic seals, the Commission for the Conservation of Antarctic Marine Living Resources, and the Scientific Committee on Antarctic Research.

2 The Commission shall cooperate with the United Nations, its relevant Specialized Agencies, and, as appropriate, any international organization which may have competence in respect of mineral resources in areas adjacent to those covered by this Convention.

3 The Commission shall also, as appropriate, cooperate with the International Union for the Conservation of Nature and Natural Resources, and with other relevant international organizations, including non-governmental organizations, having a scientific, technical or environmental interest in Antarctica.

4 The Commission may, as appropriate, accord observer status in the Commission and in the Advisory Committee to such relevant international organizations, including non-governmental organizations, as might assist in the work of the institution in question. Observer status at a Special Meeting of Parties shall be open to such organizations as have been accorded observer status in the Commission or the Advisory Committee.

5 The Commission may enter into agreements with the organizations referred to in this Article.

Article 35

Financial Provisions

1 The Commission shall adopt a budget, on an annual or other appropriate basis, for:

(a) its activities and the activities of Regulatory Committees, the Advisory Committee, the Special Meeting of Parties, any subsidiary bodies established and the Secretariat; and

(b) the progressive reimbursement of any contributions paid under paragraphs 5 and 6 below whenever revenues under paragraph 4 below exceed expenditure.

2 The first draft budget shall be submitted by the Depositary at least 90 days before the first meeting of the Commission. At that meeting the Commission shall adopt its first budget and decide upon arrangements for the preparation of subsequent budgets.

3 The Commission shall adopt financial regulations.

4 Subject to paragraph 5 below, the budget shall be financed, *inter alia, by:*

(a) fees prescribed pursuant to Articles 21(l) (p) and 43 (2) (b)

(b) levies on Operators, subject to any measures adopted by the Commission in accordance with Article 21(1) (q), pursuant to Article 47(k) (i); and

(c) such other financial payments by Operators pursuant to Article 47(k) (ii) as may be required to be paid to the institutions of this Convention.

5 If the budget is not fully financed by revenues in accordance with paragraph 4 above, and subject to reimbursement in accordance with paragraph l(b) above, the budget shall, to the extent of any shortfall and subject to paragraph 6 below, be financed by contributions from the members of the Commission. To this end, the Commission shall adopt as soon as possible a method of equitable sharing of contributions to the budget. The budget shall, in the meantime, to the extent of any shortfall, be financed by equal contributions from each member of the Commission.

6 In adopting the method of contributions referred to in paragraph 5 above the Commission shall consider the extent to which members of and observers at institutions of this Convention may be called upon to contribute to the costs of those institutions.

7 The Commission, in determining the disposition of revenues accruing to it, which are surplus to the requirements for financing the budget pursuant to this Article, shall:

(a) promote scientific research in Antarctica, particularly that related to the Antarctic environment and Antarctic resources, and a wide spread of participation in such research by all Parties, in particular developing country Parties;

(b) ensure that the interests of the members of Regulatory Committees having the most direct interest in the matter in relation to the areas in question are respected in any disposition of that surplus.

8 The finances of the Commission, Regulatory Committees, the Advisory Committee, the Special Meeting of Parties, any subsidiary bodies established and the Secretariat shall accord with the financial regulations adopted by the Commission and shall be subject to an annual audit by external auditors selected by the Commission.

9 Each member of the Commission, Regulatory Committees, the Advisory Committee, the Special Meeting of Parties and any subsidiary bodies established, as well as any observer at a meeting of any of the institutions of this Convention, shall meet its own expenses arising from attendance at meetings.

10 A member of the Commission that fails to pay its contribution for two consecutive years shall not, during the period of its continuing subsequent default, have the right to participate in the taking of decisions in any of the institutions of this Convention, If it continues to be in default for a further two consecutive years, the Commission shall decide what further action should be taken, which may include loss by that member of the right to participate in meetings of the institutions of this Convention. Such member shall resume the full enjoyment of its rights upon payment of the outstanding contributions.

11 Nothing in this Article shall be construed as prejudicing the position of any member of a Regulatory Committee on the outcome of consideration by the Regulatory Committee of terms and conditions in a Management Scheme pursuant to Article 47 (k) (ii)

Article 36

Official and Working Languages

The official and working languages of the Commission, Regulatory Committees, the Advisory Committee, the Special Meeting of Parties and any meeting convened under Article 64 shall be English, French, Russian and Spanish.

CHAPTER III: PROSPECTING

Article 37

Prospecting

1 Prospecting shall not confer upon any Operator any right to Antarctic mineral resources.

2 Prospecting shall at all times be conducted in compliance with this Convention and with measures in effect pursuant to this Convention, but shall not require authorization by the institutions of this Convention.

3 (a) The Sponsoring State shall ensure that its Operators undertaking prospecting maintain the necessary financial and technical means to comply with Article 8(1), and, to the extent that any such Operator fails to take response action as required in Article 8(1), shall ensure that this is undertaken.

(b) The Sponsoring State shall also ensure that its Operators undertaking prospecting maintain financial capacity, commensurate with the nature and level of the activity undertaken and the risks involved, to comply with Article 8(2).

4 In cases where more than one Operator is engaged in prospecting in the same general area, the Sponsoring state or States shall ensure that those Operators conduct their activities with due regard to each others' rights.

5 Where an Operator wishes to conduct prospecting in an area identified under Article 41 in which another Operator has been authorized to undertake exploration or development the Sponsoring State shall ensure that such prospecting is carried out subject to the rights of any authorized Operator and any requirements to protect its rights specified by the relevant Regulatory Committee.

6 Each Operator shall ensure upon cessation of prospecting the removal of all installations and equipment and site rehabilitation. On the request of the Sponsoring State, the Commission may waive the obligation to remove installations and equipment.

7 The Sponsoring State shall notify the Commission at least nine months in advance of the commencement of planned prospecting. The notification shall be accompanied by such fees as may be established by the Commission in accordance with Article 21(1) (p) and shall:

(a) identify, by reference to coordinates of latitude and longitude or identifiable geographic features, the general area in which the prospecting to take place;

(b) broadly identify the mineral resource or resources which are to be the subject of the prospecting;

(c) describe the prospecting, including the methods to be used, and the general program of work to be undertaken and its expected duration;

(d) provide an assessment of the possible environmental and other impacts of the prospecting, taking into account possible cumulative impacts as referred to in Article 4(5);

(e) describe the measures, including monitoring programs, to be adopted to avoid harmful environmental consequences or undue interference with other established uses of Antarctica, and outline the measures to be put into effect in the event of any accident and contingency plans for evacuation in an emergency;

(f) provide details on the Operator and certify that it:

(i) has a substantial and genuine link with the Sponsoring State as defined in Article 1(12); and

(ii) is financially and technically qualified to carry out the proposed prospecting in accordance with this Convention; and

(g) provide such further information as may be required by measures adopted by the Commission.

8 The Sponsoring State shall subsequently provide to the Commission:

(a) notification of any changes to the information referred to in paragraph 7 above;

(b) notification of the cessation of prospecting, including removal of any installations and equipment as well as site rehabilitation; and

(c) a general annual report on the prospecting undertaken by the Operator.

9 Notifications and reports submitted pursuant to this Article shall be circulated by the Executive Secretary without delay to all Parties and observers attending Commission meetings.

10 Paragraphs 7,8 and 9 above shall not be interpreted as requiring the disclosure of data and information of commercial value.

11 The Sponsoring State shall ensure that basic data and information of commercial value generated by prospecting are maintained in archives and may at any time release part of or all such data and information, on conditions which it shall establish, for scientific or environmental purposes.

12 The Sponsoring State shall ensure that basic data and information, other than interpretative data, generated by prospecting are made readily available when such data and information are not or are no longer, of commercial value and, in any event, no later than 10 years after the year the data and information were collected, unless it certifies to the Commission that the data and information continue to have commercial value. It shall review at regular intervals whether such data and information may be released and shall report the results of such reviews to the Commission.

13 The Commission may adopt measures consistent with this Article relating to the release of data and information of commercial value including requirements for certifications, the frequency of reviews and maximum time limits for extensions of the protection of such data and information.

Artic1438

Consideration of Prospecting by the Commission

1 If a member of the Commission considers that a notification submitted in accordance with Article 37(7) or (8), or ongoing prospecting, causes concern as to consistency with this Convention or measures in effect pursuant thereto, that member may request the Sponsoring State to provide a clarification. If that member considers that an adequate response is not forthcoming from the Sponsoring State within a reasonable time, the member may request that the Commission be convened in accordance with Article 19(2) (b) to consider the question and take appropriate action.

2 If measures applicable to all relevant Operators are adopted by the Commission following a request made in accordance with paragraph 1 above, Sponsoring States that have submitted notifications in accordance with Article 37(7) or (8), and Sponsoring States whose Operators are conducting prospecting, shall ensure that the plans and activities of their Operators are modified to the extent necessary to conform with those measures within such time limit as the Commission may prescribe, and shall notify the Commission accordingly,

CHAPTER IV: EXPLORATION

Article 39

Requests for Identification of an Area for Possible Exploration and Development

1 Any Party may submit to the Executive Secretary a notification requesting that the Commission identify an area for possible exploration and development of a particular mineral resource or resources.

2 Any such notification shall be accompanied by such fees as may be established by the Commission in accordance with Article 21(1) (p) and shall contain:

(a) precise delineation, including coordinates, of the area proposed for identification;
(b) specification of the resource or resources for which the area would be identified and any relevant data and information, excluding data and information of commercial value, concerning that resource or those resources, including a geological description of the proposed area;
(c) a detailed description of the physical and environmental characteristics of the proposed area;
(d) a description of the likely scale of exploration and development for the resource or resources involved in the proposed area and of the methods which could be employed in such exploration and development;
(e) a detailed assessment of the environmental and other impacts of possible exploration and develop ment for the resource or resources involved, taking into account Articles 15 and 26(4); and
(f) such other information as may be required pursuant to measures adopted by the Commission.

3 A notification under paragraph 1 above shall be referred promptly by the Executive Secretary to all Parties and shall be circulated to observers attending the meeting of the Commission to be convened pursuant to Article 19(2) (a)

Article 40

Action by the Advisory Committee and Special Meeting of Parties

1 The Advisory Committee shall meet as soon as possible after the meeting of the Commission convened pursuant to Article 19 (2) (a) has commenced. The Advisory Committee shall provide advice to the Commission on the notification submitted pursuant to Article 39(1) The Commission may prescribe a time limit for the provision of such advice.

2 A Special Meeting of Parties shall meet as soon as possible after circulation of the report of the Advisory Committee and in any event not later than two months after that report has been circulated.

3 The Special Meeting of Parties shall consider whether identification of an area by the Commission in accordance with the request contained in the notification would be consistent with this Convention, and shall report thereon to the Commission as soon as possible and in any event not later than 21 days from the commencement of the meeting.

4 The report of the Special Meeting of Parties to the Commission shall reflect the conclusions reached and all the views expressed by Parties participating in the meeting.

Article 41

Action by the Commission

1 The Commission shall, as soon as possible after receipt of the report of the Special Meeting of Parties, consider whether or not it will identify an area as requested. Taking full account of the views and giving special weight to the conclusions of the Special Meeting of Parties, and taking full account of the views and the conclusions of the Advisory Committee, the Commission shall determine whether such identification would be consistent with this Convention. For this purpose:

(a) the Commission shall ensure that an area to be identified shall be such that, taking into account all factors relevant to such identification, including the physical, geological, environmental and other characteristics of such area, it forms a coherent unit for the purposes of resource management. The Commission shall thus consider whether an area to be identified should include all or part of that which was requested in the notification and, subject to the necessary assessments having been made, adjacent areas not covered by that notification;
(b) the Commission shall consider whether there are, within an area requested or to be identified, any areas in which exploration and develop ment are or should be prohibited or restricted in accordance with Article 13;
(c) the Commission shall specify the mineral resource or resources for which the area would be identified;
(d) the Commission shall give effect to Article 6, by elaborating opportunities for joint ventures *or* different forms of participation, up to a defined level, including procedures for offering such participation, in possible exploration and develop ment, within the area, by interested Parties

which are Antarctic Treaty Consultative Parties and by other interested Parties, in particular, developing countries in either category;

(e) the Commission shall prescribe any additional associated conditions necessary to ensure that an area to be identified is consistent with other provisions of this Convention and may prescribe general guidelines relating to the operational requirements for exploration and development in an area to be identified including measures establishing maximum block sizes and advice concerning related support activities; and

(f) the Commission shall give effect to the requirement in Article 59 to establish additional procedures for the settlement of disputes.

2 After it has completed its consideration in accordance with paragraph 1 above, the Commission shall identify an area for possible exploration and development if there is a consensus of Commission members that such identification is consistent with this Convention.

Article 42

Revision in the Scope of an Identified Area

1 If, after an area has been identified in accordance with Article 41, a Party requests identification of an area, all or part of which is contained within the boundaries of the area already identified but In respect of a mineral resource or resources different from any resource in respect of which the area has already been identified, the request shall be dealt within accordance with Articles 39, 40 and 41. Should the Commission identify an area in respect of such different mineral resource or resources, it shall have regard, in addition to the requirements of Article 41(1) (a), to the desirability of specifying the boundaries of the area in such away that it can be assigned to the Regulatory Committee with competence for the area already identified.

2 In the light of increased knowledge bearing on the effective management of the area, and after seeking the views of the Advisory Committee and the relevant Regulatory Committee, the Commission may amend the boundaries of any area it has identified. In making any such amendment the Commission shall ensure that authorized exploration and development in the area are not adversely affected. Unless there are compelling reasons for doing so, the Commission shall not amend the boundaries of an area it has identified in such a way as to involve a change in the composition of the relevant Regulatory Committee.

Article 43

Preparatory Work by Regulatory Committees

1 As soon as possible after the identification of an area pursuant to Article 41, the relevant Regulatory Committee established in accordance with Article 29 shall be convened.

2 The Regulatory Committee shall:

(a) subject to any measures adopted by the Commission pursuant to Article 21(1) (j) relating to maximum block sizes, divide its area of competence into blocks in respect of which applications for exploration and development may be submitted and make provision for a limit in appropriate circumstances on the number of blocks to be accorded to any Party;

(b) subject to any measures adopted by the Commission pursuant to Article 21(1) (p), establish fees to be paid with any application for an exploration or development permit lodged pursuant to Article 44 or 53;

(c) establish periods within which applications for exploration and development may be lodged, all applications received within each such period being considered as simultaneous;

(d) establish procedures for the handling of applications; and

(e) determine a method of resolving competing applications which are not resolved in accordance with Article 45(4) (a), which method shall, provided that all other requirements of this Convention are satisfied and consistently with measures adopted pursuant to Article41 (1) (d), include priority for the application with the broadest participation among interested Parties which are Antarctic Treaty Consultative Parties and other interested Parties, in particular, developing countries in either category.

3 The Regulatory Committee shall adopt guidelines which are consistent with, and which taken together with, the provisions of this Convention and measures of general applicability adopted by the Commission, as well as associated conditions and general guidelines adopted by the Commission when identifying the area, shall, by addressing the relevant items in Article 47, identify the general requirements for exploration and development in its area of competence.

4 Upon adoption of guidelines under paragraph 3 above the Executive Secretary shall, without delay, inform all members of the Commission of the decisions taken by the Regulatory Committee pursuant to paragraphs 2 and 3 above and shall make them publicly

available together with relevant measures, associated conditions and general guidelines adopted by the Commission.

5 The Regulatory Committee may from time to time revise guidelines adopted under paragraph 3 above, taking into account any views of the Commission.

6 In performing its functions under paragraphs 3 and 5 above, the Regulatory Committee shall seek and take full account of the views of the Advisory Committee provided in accordance with Article 26.

Article 44

Application for an Exploration Permit

1 Following completion of the work undertaken pursuant to Article 43, any Party, on behalf of an Operator for which it is the Sponsoring State, may lodge with the Regulatory Committee an application for an exploration permit within the periods established by the Regulatory Committee pursuant to Article 43 (2) (c).

2 An application shall be accompanied by the fees established by the Regulatory Committee in accordance with Article 43(2) (b) and shall contain:

- (a) detailed description of the Operator, including its managerial structure, financial composition and resources and technical expertise, and, in the case of an Operator being a joint venture, the inclusion of a detailed description of the degree to which Parties are involved in the Operator through, *inter alia, juridical* persons with which Parties have substantial and genuine links, so that each component of the joint venture can be easily attributed to a Party or Parties for the purposes of identifying the level of Antarctic mineral resource activities thereof, which description of substantial and genuine links shall include a description of equity sharing;
- (b) a detailed description of the proposed exploration activities and a description in as much detail as possible of proposed development activities, including:
  - (i) an identification of the mineral resource or resourecs and the block to which the application applies;
  - (ii) a detailed explanation of how the proposed activities conform with the general requirements referred to in Article 43(3);
  - (iii) a detailed assessment of the environmental and other impacts of the proposed activities, taking into account Articles 15 and 26(4); and
  - (iv) a description of the capacity to respond effectively to accidents, especially those with potential environmental effects;
- (c) a certification by the Sponsoring State of the capacity of the Operator to comply with the general requirements referred to in Article 43(3);
- (d) a certification by the Sponsoring State of the technical competence **and** financial capacity of the Operator and that the Operator has a substantial and genuine link with it as defined in Article 1(12);
- (e) a description of the manner in which the application complies with any measures adopted by the Commission pursuant to Article 41(1) (d); and
- (f) such further information as may be required by the Regulatory Committee or in measures adopted by the Commission.

Article 45

Examination of Applications

1 The Regulatory Committee shall meet as soon as possible after an application has been lodged pursuant to Article 44, for the purpose of elaborating a Management Scheme. In performing this function it shall:

- (a) determine whether the application contains sufficient or adequate information pursuant to Article 44 (2). To this end, it may at any time seek further information from the Sponsoring State consistent with Article 44(2);
- (b) consider the exploration and development activities proposed in the application, and such elaborations, revisions or additions as neces-
  - (i) to ensure their consistency with this Convention as well as measures in effect pursuant thereto and the general requirements referred to in Article 43(3); and
  - (ii) to prescribe the specific terms and conditions of a Management Scheme in accordance with Article 47.

2 At any time during the process of consideration described above, the Regulatory Committee may decline the application if it considers that the activities proposed therein cannot be elaborated, revised or adapted to ensure consistency with this Convention as well as measures in effect pursuant thereto and the general requirements referred to in Article 43(3).

3 In performing its functions under this Article, the Regulatory Committee shall seek and take full account of the views of the Advisory Committee. To that *end the* Regulatory Committee shall refer to the Advisory Committee all parts of the application which are necessary for it to provide advice pursuant to Article 26, together with any other relevant information.

4 If two or more applications meeting the requirements of Article **44(2) are lodged in respect of the same** block:

(a) **the competing applicants shall be invited by the Regulatory Committee to resolve the competition amongst themselves, by means of their own choice** within a prescribed period;

(b) if the competition is not resolved pursuant to subparagraph (a) above it shall be resolved by the Regulatory Committee in accordance with the method determined by it pursuant to Article 43(2) (e),

Article 46

Management Scheme

In performing its functions under Article 45, including the preparation of a Management Scheme, and under Article 54, the Regulatory Committee shall have recourse to the Sponsoring State and the member or members, if any, referred to in Article 29 (2) (a) and, as may be required one or two additional members of the Regulatory Committee.

Article 47

Scope of the Management Scheme

The Management Scheme shall prescribe the specific terms and conditions for exploration and development of the mineral resource or resources concerned within the relevant block. Such terms and conditions shall be consistent with the general requirements referred to in Article 43(3), and shall cover, *inter alia:*

(a) duration of exploration and development permits;

(b) measures and procedures for the protection of the Antarctic environment and dependent and associated ecosystems, including methods, activities and undertakings by the Operator to minimize environmental risks and damage;

(c) provision for necessary and timely response action, including prevention, containment and clean up and removal measures, for restoration to the ***status quo** ante*, and for contingency plans, resources and equipment to enable such action to be taken;

(d) procedures for the implementation of different stages of exploration and development;

(e) performance requirements;

(f) technical and safety specifications, including standards and procedures to ensure safe operations;

(g) monitoring and inspection;

(h) liability;

(i) procedures for the development of mineral deposits which extend outside the area covered by a permit;

(j) resource conservation requirements;

(k) financial obligations of the Operator including:

(i) levies in accordance with measures adopted pursuant to Article 21(1) (q)

(ii) payments in the nature of and similar to taxes, royalties or payments in kind;

(1) financial guarantees and insurance;

(m) assignment and relinquishment;

(n) suspension and modification of the Management Scheme, or cancellation of the Management Scheme, exploration or development permit, and the imposition of monetary penalties, in accordance with Article 51;

(o) procedures for agreed modifications;

(p) enforcement of the Management Scheme;

(q) applicable law to the extent necessary;

(r) effective additional procedures for the settlement of disputes:

(s) provisions to avoid and to resolve conflict with other legitimate uses of Antarctica;

(t) data and information collection, reporting and notification requirements;

(u) confidentiality; and

(v) removal of installations and equipment, as well as site rehabilitation.

Article 48

Approval of the Management Scheme

A Management Scheme prepared in accordance with Articles 45, 46 and 47 shall be subject to approval pursuant to Article 32. Such approval shall constitute authorization for the issue without delay of an exploration permit by the Regulatory Committee. The exploration permit shall accord exclusive rights to the Operator to explore and, subject to Articles 53 and 54, to develop the mineral resource or resources which are the subject of the Management Scheme exclusively in accordance with the terms and conditions of the Management Scheme,

Article 49

Review

1 Any member of the Commission, or any member of a Regulatory Committee, may within one month of a decision by that Regulatory Committee to approve a Management Scheme or issue a development permit, request that the Commission be convened in accordance with Article 19(2) (b) or(c), as the case may be, to review the decision of the Regulatory Committee for consistency with the decision taken by the Commission to identify the area pursuant to Article 41 and any measures in effect relevant to that decision.

2 The Commission shall complete its consideration within three months of a request made pursuant to paragraph 1 above, In performing its functions the Commission shall not assume the functions of the Regulatory Committee, nor shall substitute its discretion for that of the Regulatory Committee.

3 Should the Commission determine that a decision to approve a Management Scheme or issue a development permit is inconsistent with the decision taken by the Commission to identify the area pursuant to Article 41 and any measures in effect relevant to that Decision, it may request that Regulatory Committee to reconsider its decision.

Article 50

Rights of Authorized Operators

1 No Management Scheme shall be suspended or modified and no Management Scheme, exploration or development permit shall be canceled without the consent of the Sponsoring State except pursuant to Article 51, or Article 54 or the Management Scheme itself,

2 Each Operator authorized to conduct activities pursuant to a Management Scheme shall exercise its rights with due regard to the rights of other Operators undertaking exploration or development in the same identified area,

Article 51

Suspension, Modification or Cancellation of the Management Scheme and Monetary Penalties

1 If a Regulatory Committee determines that exploration or development authorized pursuant to a Management Scheme has resulted or is about to result in impacts on the Antarctic environment or dependent or associated ecosystems beyond those judged acceptable pursuant to this Convention, it shall suspend the relevant activities and as soon as possible modify the Management Scheme so as to avoid such impacts. If such impacts cannot be avoided by the modification of the Management Scheme, the Regulatory Committee shall suspend it, or cancel it and the exploration or development permit.

2 In performing its functions under paragraph 1 above a Regulatory Committee shall, unless emergency action is required, seek and take into account the views of the Advisory Committee.

3 If a Regulatory Committee determines that an Operator has failed to comply with this Convention or with measures in effect pursuant to it or a Management Scheme applicable to that Operator, the Regulatory Committee may do all or any of the following:

(a) modify the Management Scheme;
(b) suspend the Management Scheme;
(c) cancel the Management Scheme and the exploration or development permit; and
(d) impose a monetary penalty.

4 Sanctions determined pursuant to paragraph 3(a) to (d) above shall be proportionate to the seriousness of the failure to comply.

5 A Regulatory Committee shall cancel a Management Scheme and the exploration or development permit if an Operator ceases to have a substantial and genuine link with the Sponsoring State as defined in Article 1(12).

6 The Commission shall adopt general measures, which may include mitigation, relating to action by Regulatory Committees pursuant to paragraphs 1 and 3 above and, as appropriate, to the consequences of such action. No application pursuant to Article 44 may be lodged until such measures have come into effect.

Article 52

Monitoring in Relation to Management Schemes

1 Each Regulatory Committee shall monitor the compliance of Operators with Management Schemes within its area of competence.

2 Each Regulatory Committee, taking into account the advice of the Advisory Committee, shall monitor and assess the effects on the Antarctic environment and on dependent and on associated ecosystems of Antarctic mineral resource activities within its area of competence, particularly by reference to key environmental parameters and ecosystem components.

3 Each Regulatory Committee shall, as appropriate, inform the Commission and the Advisory Committee in a timely fashion of monitoring under this Article.

CHAPTER V: DEVELOPMENT

Article 53

Application for a Development Permit

1 At any time during the period in which art approved Management Scheme and exploration permit are in force for an Operator, the Sponsoring State may, on behalf of that Operator, lodge with the Regulatory Committee an application for a development permit.

2 An application shall be accompanied by the fees established by the Regulatory Committee in accordance with Article 43(2) (b) and shall contain:

(a) an updated description of the planned development identifying any modifications proposed to the approved Management Scheme and any additional measures to be taken, consequent upon such modifications, to ensure consistency with this convention, including any measures in effect pursuant thereto and the general requirements refereed to in Article 43(3);

(b) a detailed assessment of the environmental and other impacts of the planned development, taking into account Articles 15 and 26(4);

(c) a recertification by the Sponsoring State of the technical competence and financial capacity of the Operator and that the Operator has a substantial and genuine link with it as defined in Article 1(12);

(d) a recertification by the Sponsoring State of the capacity of the Operator to comply with the general requirements referred to in Article 43(3);

(e) updated information in relation to all other matters specified in Article 44(2); and

(f) such further information as may be required by the Regulatory Committee or in measures adopted by the Commission.

Article 54

Examination of Applications and Issue of Development Permits

1 The Regulatory Committee shall meet as soon as possible after an application has been lodged pursuant to Article 53₀

2 The Regulatory Committee shall determine whether the application contains sufficient or adequate information pursuant to Article 53 (2), In performing this function it may at any time seek further information from the Sponsoring State consistent with Article 53(2).

3 The Regulatory Committee shall consider whether:

(a) the application reveals modifications to the planned development previously envisaged;

(b) the planned development would cause previously unforseen impacts on the Antarctic environment or dependent or associated ecosystems, either as a result of any modifications referred to in sub paragraph (a) above or in the light of increased knowledge.

4 The Regulatory Committee shall consider any modifications to the Management Scheme necessary in the light of paragraph 3 above to ensure that the development activities proposed would be undertaken consistently with this Convention as well as measures in effect pursuant thereto and the general requirements referred to in Article 43(3). However, the financial obligations specified in the approved Management Scheme may not be revised without the consent of the Sponsoring State, unless provided for in the Management Scheme itself.

5 If the Regulatory Committee in accordance with Article 32 approves modifications under paragraph 4 above, or if it does not consider that such modifications are necessary, the Regulatory Committee shall issue without delay a development permit.

6 In performing its functions under this Article, the Regulatory Committee shall seek and take full account of the views of the Advisory Committee. To that end the Regulatory Committee shall refer to the Advisory Committee all parts of the application which are necessary for it to provide advice pursuant to Article 26, together with any other relevant information.

CHAPTER VI: DISPUTES SETTLEMENT

Article 55

Disputes Between Two or More Parties

Articles 56, 57 and 58 apply to disputes between two or more Parties.

Article 56

Choice of Procedure

1 Each Party, when signing, ratifying, accepting, approving or acceding to this Convention, or at any time thereafter, may choose, by written declaration, one or both of the following means for the settlement of disputes concerning the interpretation or application of this Convention:

(a) the International Court of Justice;
(b) the Arbitral Tribunal.

2 A declaration made under paragraph 1 above shall not affect the operation of Article 57(l), (3), (4) and (5).

3 A Party that has not made a declaration under paragraph 1 above or in respect of which a declaration is no longer in force shall be deemed to have accepted the competence of the Arbitral Tribunal.

4 If the parties to a dispute have accepted the same means for the settlement of a dispute, the dispute may be submitted only to that procedure, unless the parties otherwise agree.

5 If the parties to a dispute have not accepted the same means for the settlement of a dispute, or if they have both accepted both means, the dispute may be submitted only to the Arbitral Tribunal, unless the parties otherwise agree.

6 A declaration made under paragraph 1 above shall remain in force until it expires in accordance with its terms or until 3 months after written notice of revocation has been deposited with the Depositary.

7 A new declaration, a notice of revocation or the expiry of a declaration shall not in any way affect proceedings pending before the International Court of Justice or the Arbitral Tribunal, unless the parties to the dispute otherwise agree.

8 Declarations and notices referred to in this Article shall be deposited with the Depositary who shall transmit copies thereof to all Parties.

Article 57

Procedure for Dispute Settlement

1 If a dispute arises concerning the interpretation or application of this Convention, the parties to the dispute shall, at the request of any one of them, consult among themselves as soon as possible with a view to having the dispute resolved by negotiation, enquiry, mediation, conciliation, arbitration, judicial settlement or other peaceful means of their choice.

2 If the parties to a dispute concerning the interpretation or application of this Convention have not agreed on a means for resolving it within 12 months of the request for consultation pursuant to paragraph 1 above, the dispute shall be referred, at the request of any party to the dispute, for settlement in accordance with the procedure determined by the operation of Article 56(4) and (5).

3 If a dispute concerning the interpretation or application of this Convention relates to a measure in effect pursuant to this Convention or a Management Scheme and the parties to such a dispute:

- (a) have not agreed on a means for resolving the dispute within 6 months of the request for consultation pursuant to paragraph 1 above, the dispute shall be referred, at the request of any party to the dispute, for discussion in the institution which adopted the instrument in question;
- (b) have not agreed on a means for resolving the dispute within 12 months of the request for consultation pursuant to paragraph 1 above, the dispute shall be referred for settlement at the request of any party to the dispute, to the Arbitral Tribunal.

4 The Arbitral Tribunal shall not be competent to decide or otherwise rule upon any matter within the scope of Article **9.** In addition, nothing in this Convention shall be interpreted as conferring competence or jurisdiction on the Intemational Court of Justice or any other tribunal established for the purpose of settling disputes between Parties to decide or otherwise rule upon any matter within the scope of Article 9.

5 The Arbitral Tribunal shall not be competent with regard to the exercise by an institution of its discretionary powers in accordance with this Convention; in no case shall the Arbitral Tribunal substitute its discretion for that of an institution. In addition, nothing in this Convention shall be interpreted as conferring competence or jurisdiction on the International Court of Justice or any other tribunal established for the purpose of settling disputes between Parties with regard to the exercise by an institution of its discretionary powers or to ***substitute*** its discretion for that of an institution.

Article 58

Exclusion of Categories of Disputes

1 Any Party, when signing, ratifying, accepting, approving or acceding to this Convention, or at any time thereafter, may, by written declaration, exclude the operation of Article 57(2) or (3) without its consent with respect to a category or categories of disputes specified in the declaration. Such declaration may not cover disputes concerning the interpretation or application of:

- (a) any provision of this Convention or of any measure in effect pursuant to it relating to the protection of the Antarctic environment or dependent or associated ecosystems;
- (b) Article 7(l);
- (c) Article 8;
- (d) Article 12;
- (e) Article 14;
- (f) Article 15; or
- (g) Article 37.

2 Nothing in paragraph 1 above or in any declaration made under it shall affect the operation of Article 57(l), (4) and (5).

3 A declaration made under paragraph 1 above shall remain in force until it expires in accordance with its terms or until 3 months after written notice of revocation has been deposited with the Depositary.

4 A new declaration, a notice of revocation or the expiry of a declaration shall not in any way affect proceedings pending before the International Court of Justice or the Arbitral Tribunal, unless the parties to the dispute otherwise agree.

5 Declarations and notices referred to in this Article shall be deposited with the Depositary who shall transmit copies thereof to all Parties.

6 A Party which, by declaration made under paragraph 1 above, has excluded a specific category or categories of disputes from the operation of Article 57(2) or (3) without its consent shall not be entitled to submit any dispute falling within that category or those categories for settlement pursuant to Article 57(2) or (3), as the case may be, without the consent of the other party or parties to the dispute.

Article 59

Additional Dispute Settlement Procedures

1 **The** Commission, in conjunction with its responsibilities pursuant to Article 41(1), shall establish additional procedures for third-party settlement, by the Arbitral Tribunal or through other similar procedures, of disputes which may arise if it is alleged that a violation of this Convention has occurred by virtue of:

(a) a decision to decline a Management Scheme;
(b) a decision to decline the issue of a development permit; or
(c) a decision to suspend, modify or cancel a Management Scheme or to impose monetary penalties.

2 Such procedures shall:

(a) permit, as appropriate, Parties and Operators under their sponsorship, but not both in respect of any particular dispute, to initiate proceedings against a Regulatory Committee;
(b) require disputes to which they relate to be referred in the first instance to the relevant Regulatory Committee for consideration;
(c) incorporate the rules in Article 57(4) and (5).

CHAPTER VII: FINAL CLAUSES

Article 60

Signature

This Convention shall be open for signature at Wellington from 25 November 1988 to 25 November 1989 by States which participated in the final session of the Fourth Special Antarctic Treaty Consultative Meeting.

Article 61

Ratification, Acceptance, Approval or Accession

1 This Convention is subject to ratification, acceptance or approval by Signatory States.

2 After 25 November 1989 this Convention shall be open for accession by any State which is a Contracting Party to the Antarctic Treaty.

3 Instruments of ratification, acceptance, approval or accession shall be deposited with the Government of New Zealand, hereby designated as the Depositary.

Article 62

Entry Into Force

1 This Convention shall enter into force on the thirtieth day following the date of deposit of instruments of ratification, acceptance, approval or accession by 16 Antarctic Treaty Consultative Parties which participated as such *in the* final session of the Fourth Special Antarctic Treaty Consultative Meeting, provided that number includes all the States necessary in order to establish all of the institutions of the Convention in respect of every area of Antarctica, including 5 developing countries and 11 developed countries.

2 For each State which, subsequent to the date of entry into force of this Convention, deposits an instrument of ratification, acceptance, approval or accession, the Convention shall enter into force on the thirtieth day following such deposit.

Article 63

Reservations, Declarations and Statements

1 Reservations to this Convention shall not be permitted. This does not preclude a State, when signing, ratifying, accepting, approving or acceding to this Convention, from making declarations or statements, however phrased or named, with a view, *inter* alia, to the harmonization of *its* laws and regulations with this Convention, provided that such declarations or statements do not purport to exclude or to modify the legal effect of this Convention in its application to that State.

2 The provisions of this Article are without prejudice to the right to make written declarations in accordance with Article 58.

Article 64

Amendment

1 This Convention shall not be subject to amendment until after the expiry of 10 years from the date of its entry into force. Thereafter, any Party may, by written communication addressed to the Depositary, propose a specific amendment to this Convention and request the convening of a meeting to consider such proposed amendment.

2 The Depositary shall circulate such communication to all Parties. If within 12 months of the date of circulation of the communication at least one-third of the Parties reply favorably to the request, the Depositary shall convene the meeting.

3 The adoption of an amendment considered at such a meeting shall require the affirmative votes of two-thirds of the Parties present and voting, including the concurrent votes of the members of the Commission attending the meeting.

4 The adoption of any amendment relating to the Special Meeting of Parties or to the Advisory Committee shall require the affirmative votes of three-quarters of the Parties present and voting, including the concurrent votes of the members of the Commission attending the meeting.

5 An amendment shall enter into force for those Parties having deposited instruments of ratification, acceptance or approval thereof 30 days after the Deposi-

tary has received such instruments of ratification, acceptance or approval from all the members of the Commission.

6 Such amendment shall thereafter enter into force for any other Party 30 days after the Depositary has received its instrument of ratification, acceptance or approval thereof.

7 An amendment that has entered into force pursuant to this Article shall be without prejudice to the provisions of any Management Scheme approved before the date on which the amendment entered into force.

Article 65

Withdrawal

1 Any Party may withdraw from this Convention by giving to the Depositary notice in writing of its intention to withdraw, Withdrawal shall take effect two years after the date of receipt of such notice by the Depositary.

2 Any Party which ceases to be a Contracting Party to the Antarctic Treaty shall be deemed to have withdrawn from this Convention on the date that it ceases to be a Contracting Party to the Antarctic Treaty.

3 Where an amendment has entered into force pursuant to Article 64(5), any Party from which no instrument of ratification, acceptance or approval of the amendment has been received by the Depositary within a period of two years from the date of the entry into force of the amendment shall be deemed to have withdrawn from this Convention on the date of the expiration of a further two year period.

4 Subject to paragraphs 5 and 6 below, the rights and obligations of any Operator pursuant to this Convention shall cease at the time its Sponsoring State withdraws or is ***deemed*** to have withdrawn from this Convention.

5 Such Sponsoring State shall ensure that the obliga*tions* of its Operators have been discharged no later than the date on which its withdrawal takes effect.

6 Withdrawal from this Convention by any Party shall not affect its financial or other obligations under this Convention pending on the date withdrawal takes effect. Any dispute settlement procedure in which that Party is involved and which has been commenced prior to that date shall continue to its conclusion unless agreed otherwise by the parties to the dispute.

Article 66

Notifications by the Depositary

The Depositary shall notify all Contracting Parties to the Antarctic Treaty of the following:

(a) signatures of this Convention and the deposit of instruments of ratification, acceptance, approval or accession;

(b) the deposit of instruments of ratification, acceptance or approval of any amendment adopted pursuant to Article 64;

(c) the date of entry into force of this Convention and of any amendment thereto;

(d) the deposit of declarations and notices pursuant to Articles 56 and 58;

(e) notifications pursuant to Article 18; and

(f) the withdrawal of a Party pursuant to Article 65.

Article 67

Authentic Texts, Certified Copies And Registration With the United Nations

1 This Convention of which the Chinese, English, French, Russian and Spanish texts are equally authentic shall be deposited with the Government of New Zealand which shall transmit duly certified copies thereof to all Signatory and Acceding States,

2 The Depositary shall also transmit duly certified copies to all Signatory and Acceding States of the text of this Convention in any additional language of a Signatory or Acceding State which submits such text to the Depositary.

3 This Convention shall be registered by the Depositary pursuant to Article 102 of the Charter of the United Nations.

Done at Wellington this second day of June 1988.

In witness whereof, the undersigned, duly authorized, have signed this Convention.

ANNEX FOR AN ARBITRAL TRIBUNAL

Article 1

The Arbitral Tribunal shall be constituted and shall function in accordance with this Convention, including this Annex.

Article 2

1 Each Party shall be entitled to designate up to three Arbitrators, at least one of whom shall be designated within three months of the entry into force of this Convention for that Party. Each Arbitrator shall be experienced in Antarctic affairs, with knowledge of international law and enjoying the highest reputation for fairness, competence and integrity. The names of the persons so designated shall constitute the list of Arbitrators. Each Party shall at all times maintain the name of at least one Arbitrator on the list.

2 Subject to paragraph 3 below, an Arbitrator designated by a Party shall remain on the list for a period

of five years and shall be eligible for redesignation by that Party for additional five year periods.

3 An Arbitrator may by notice given to the Party which designated that person withdraw his name from the list. If an Arbitrator dies or gives notice of withdrawal of his name from the list or if a Party for any reason withdraws from the list the name of an Arbitrator designated by it, the Party which designated the Arbitrator in question shall notify the Executive Secretary promptly. An Arbitrator whose name is withdrawn from the list shall continue to serve on any Arbitral Tribunal to which that Arbitrator has been appointed until the completion of proceedings before that Arbitral Tribunal.

4 The Executive Secretary shall ensure that an up-to-date list is maintained of the Arbitrators designated pursuant to this Article.

Article 3

1 The Arbitral Tribunal shall be composed of three Arbitrators who shall be appointed as follows:

(a) The party to the dispute commencing the proceedings shall appoint one Arbitrator, who may be its national, from the list referred to in Article 2 of this Annex. This appointment shall be included in the notification referred to in Article 4 of this Annex.

(b) Within 40 days of the receipt of that notification, the other party to the dispute shall appoint the second Arbitrator, who may be its national, from the list referred to in Article 2 of this Annex.

(c) Within 60 days of the appointment of the second Arbitrator, the parties to the dispute shall appoint by agreement the third Arbitrator from the list referrd to in Article 2 of this Annex. The third Arbitrator shall not be either a national of, or a person designated by, a party to the dispute, or of the same nationality as either of the first two Arbitrators. The third Arbitrator shall be the Chairman of the Arbitral Tribunal.

(d) If the second Arbitrator has not been appointed within the prescribed period, or if the parties to the dispute have not reached agreement within the prescribed period on the appointment of the third Arbitrator, the Arbitrator or Arbitrators shall be appointed, at the request of any party to the dispute and within 30 days of the receipt of such request, by the Resident of the International Court of Justice from the list referred to in Article 2 of this Amex and subject to the conditions prescribed in subparagraphs (b) and (c) above. In performing the functions accorded him in this subparagraph, the Resident of the Court shall consult the parties to the dispute and the Chairman of the Commission.

(e) If the President of the International Court of Justice is unable to perform the functions accorded him in subparagraph (d) above or is a national of a party to the dispute, the functions shall be performed by the Vice-President of the Court, except that if the Vice-President is unable to perform the functions or is a national of a party to the dispute the functions shall be performed by the next most senior member of the Court who is available and is not a national of a party to the dispute.

2 Any vacancy shall be filled in the manner prescribed for the initial appointment.

3 In disputes involving more than two Parties, those Parties having the same interest shall appoint one Arbitrator by agreement within the period specified in paragraph l(b) above.

Article 4

The party to the dispute commencing proceedings shall so notify the other party or parties to the dispute and the Executive Secretary in writing. Such notification shall include a statement of the claim and the grounds on which it is based, The notification shall be transmitted by the Executive Secretary to all Parties.

Article 5

1 Unless the parties to the dispute agree otherwise, arbitration shall take place at the headquarters of the Commission, where the records of the Arbitral Tribunal shall be kept. The Arbitral Tribunal shall adopt its own rules of procedure. Such rules shall ensure that each party to the dispute has a full opportunity to be heard and to present its case and shall also ensure that the proceedings are conducted expeditiously.

2 The Arbitral Tribunal may hear and decide counterclaims arising out of the dispute.

Article 6

1 The Arbitral Tribunal, where it considers that *prima facie* it has jurisdiction under this Convention, may:

(a) at the request of any party to a dispute, indicate such provisional measures as it considers necessary to preserve the respective rights of the parties to the dispute;

(b) prescribe any provisional measures which it considers appropriate under the circumstances to prevent serious harm to the Antarctic environment or dependent or associated ecosystems, 2 The parties to a dispute shall comply promptly with any provisional measures prescribed under paragraph l(b) above pending an award under Article 9 of this Annex.

3 Notwithstanding Article 57(l), (2) and (3) of this Convention, a party to any dispute that may arise falling within the categories specified in Article 58(1) (a) to (g) of this Convention may at any time, by notification to the other party or parties to the dispute and to the Executive Secretary in accordance with Article 4 of this Annex, request that the Arbitral Tribunal be constituted as a matter of exceptional urgency to indicate or prescribe emergency provisional measures in accordance with this Article. In such case, the Arbitral Tribunal shall be constituted as soon as possible in accordance with Article 3 of this Annex, except that the time periods in Article 3(1) (b), (c) and (d) shall be reduced to 14 days in each case. The Arbitral Tribunal shall decide upon the request for emergency provisional measures within two months of the appointment of its Chairman.

4 Following a decision by the Arbitral Tribunal upon a request for emergency provisional measures in accordance with paragraph 3 above, settlement of the dispute shall proceed in accordance with Articles 56 and 57 of this Convention.

Article 7

Any Party which believes it has a legal interest, whether general or individual, which maybe substantially affected by the award of an Arbitral, Tribunal, may, unless the Arbitral Tribunal decides otherwise, intervene in the proceedings.

Article 8

The parties to the dispute shall facilitate the work of the Arbitral Tribunal and, in particular, in accordance with their law and using all means at their disposal, shall provide it with all relevant documents and information, and enable it, when necessary, to call witnesses or experts and receive their evidence.

Article 9

If one of the parties to the dispute does not appear before the Arbitral Tribunal or fails to defend its case, any other party to the dispute may request the Arbitral Tribunal to continue the proceedings and make its award.

Article 10

1 The Arbitral Tribunal shall decide, on the basis of this Convention and other rules of law not incompatible with it, such disputes as are submitted to it.

2 The Arbitral Tribunal may decide, ex *aequo et bono*, a dispute submitted to it, if the parties to the dispute so agree.

Article 11

1 Before making its award, the Arbitral Tribunal shall satisfy itself that it has competence in respect of the dispute and that the claim or counterclaim is well founded in fact and law.

2 The award shall be accompanied by a statement of reasons for the decision and shall be communicated to the Executive Secretary who shall transmit it to all Parties,

3 The award shall be final and binding on the parties to the dispute and on any Party which intervened in the proceedings and shall be complied with without delay. The Arbitral Tribunal shall interpret the award at the request of a party to the dispute or of any intervening Party.

4 The award shall have no binding force except in respect of that particular case.

5 Unless the Arbitral Tribunal decides otherwise, the expenses of the Arbitral Tribunal, including the remuneration of the Arbitrators, shall be borne by the parties to the dispute in equal shares.

Article 12

All decisions of the Arbitral Tribunal, including those referred to in Articles 5, 6 and 11 of this Annex, shall be made by a majority of the Arbitrators who may not abstain from voting.

Appendix E
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Appendix F
OTA Workshops Participants and Other Contributors

WORKSHOP PARTICIPANTS

Antarctic Oil and Gas Development Potential, Washington, D. C., Jan. 10,1989.

Participants critiqued OTA contractor reports on: a) technology and costs for offshore oil development in Antarctica, b) estimating the profitability of Antarctic oil exploitation, and c) the potential for Antarctic oil in a world liquid fuels context.

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The Convention on the Regulation of Antarctic Mineral Resource Activities, Washington, D. C., Dec. 15,1988.

Participants critiqued OTA contractor reports a) evaluating the Minerals Convention's decisionmaking system, and b) evaluating the Minerals Convention from the oil industry's perspective. Participants also discussed the Antarctic and Southern Ocean Coalition's analysis of the Convention.

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Antarctic Mining Technology and Economics, Washington, D. C., Dec. 13,1988

Participants critiqued an OTA working paper on Antarctic mineral deposits and world markets and an OTA contractor report on mining and process technology for Antarctic mineral development.

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Appendix G
Glossary

Alkaline: A group of igneous rocks in which the alkalis (Na_2O and K_2O) occur in high concentration relative to silica (SiO_2).

Asthenosphere: The upper mantle. The layer or shell of the Earth below the lithosphere (below about 100 km), which is weak and in which isostatic adjustments can take place, in which magmas may be generated, and in which seismic waves are strongly attenuated.

Base metal: Any of the more common and more chemically active metals, e.g., lead, copper, zinc.

Calc-alkaline: A group of igneous rocks in which silica occurs in high concentrations relative to the alkalis. Many of these rocks have the mineral quartz.

Ferrous metal: Iron and the metals commonly alloyed with iron in steelmaking.

Gondwana: The hypothetical protocontinent of the Southern Hemisphere, also called Gondwanaland. The preponderance of modem evidence indicates that the present continents are fragments which have been separated from each other by some form of continental displacement with the aid of seafloor spreading.

Granitic: A term used to describe light-colored, medium to coarse grained crystalline rock containing more than 10 percent quartz and richer in alkalies relative to calcium, iron, and magnesium.

Hydrothermal solutions: Hot saline solutions that pass through fractures and pore spaces in rocks. Mineral deposits can form as precipitates from hydrothermal solutions.

Iron-formation: A sedimentary rock, typically thin bedded or finely laminated, containing at least 15 percent iron and commonly but not necessarily containing layers of chert. Also called jaspilite or taconite.

Lithosphere: The crust of the Earth and upper mantle having a total thickness of approximately 100 km.

Mafic: A term used to describe dark-colored igneous rocks composed chiefly of ferromagnesian minerals.

Magmatic differentiation: The process whereby crystallization and separation of early formed minerals leads to changes in bulk composition of the residual magmatic liquids. Certain economically important ore deposits may be formed by the process.

Orogen: An erogenic belt or linear region that has been subjected to folding and other deformation during a period of tectonic activity. These regions often become mountain belts.

Placer: A surficial mineral deposit formed by mechanical concentration (usually by water) of heavy mineral particles from weathered debris.

Podiform: A term used to describe an orebody that has an elongate, lenticular shape.

Porphyritic: A term used to describe an igneous rock in which larger crystals are set in a finer groundmass which may be crystalline, glassy or both.

Precious metals: A general term for gold, silver, or any of the platinum-group metals,

Shield: A large area of exposed basement rocks in a continental land mass surrounded by younger sedimentary rocks. The rocks of virtually all shield areas are Precambrian in age.

Silicic: A general term used to describe an igneous rock or magma in which silica constitutes at least two-thirds of the rock and usually contains free silica in the form of quartz, Granite is a typical silicic rock.

Stratiform: Having the form of a bed or layer consisting of roughly parallel bands or sheets. Used to describe a layered mineral deposit, such as chromite deposits which can occur in layers up to several feet thick of fairly uniform composition and extend over large areas.

Stratigraphic trap: The sealing of a reservoir bed as a result of lithologic changes, such as the gradation of permeable sediments into impermeable sediments thus forming a barrier that can trap migrating petroleum.

Structural trap: The containment of oil or gas within a reservoir bed as a result of folding to produce a dome or anticline or faulting to bring an impermeable bed into contact with the reservoir bed creating a barrier to migration.

Ultramafic: Very dark-colored igneous rock composed chiefly of heavy minerals high in iron and magnesium.

Appendix H

Acronyms and Abbreviations

APG —Antarctic Policy Group
ATCP —Antarctic Treaty Consultative Party
ATS —Antarctic Treaty System
BLM —Bureau of Land Management
BOM —Bureau of Mines
CCAMLR -Convention on the Conservation of Antarctic Marine Living Resources
EEZ —Exclusive Economic Zone
ICSU —International Council of Scientific Unions
ICJ —International Court of Justice
IGY —International Geophysical Year
IWC —International Whaling Commission
MNAP —Managers of National Antarctic programs
MMS —Minerals Management Service
NAMRAP —National Mineral Resources Assessment Program
NCP —Non-Consultative Party
NESDIS —National Environmental Satellite Data and Information Service
NOAA —National Oceanic and Atmospheric Administration
NSC —National Security Council
NSF —National Science Foundation
ODP -Ocean Drilling program
OCS -outer continental shelf
OPEC -Organization of Petroleum Exporting Countries
PGM —Platinum Group Metals
SCAR —Scientific Committee on Antarctic Research
SPA —Specially Protected Area
SPR —Strategic Petroleum Reserve
SSS1 —Site of Special Scientific Interest
USAA —United States Antarctic Agency (possible future agency)
USGS —United States Geological Survey

Related OTA Report

- *Marine Minerals: Exploring Our New Ocean Frontier.*
  OTA-O-342, 7/87; 356 pages. GPO stock #052-003-01072-l; $15.00,
  NTIS order #PB 87-217 725/AS.

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