MINERAL DEVELOPMENT AND MINING POLICY IN GREENLAND

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ABSTRACT

The present document analyzes the economy of Greenland, a Danish self-governing territory and highlights the narrow resource base of the Greenlandic economy. To provide the foundation for an analysis of the mineral policies that have been followed in the past, and for the proposed reform of these policies, three areas of relevance are identified, economic impact and long-term sustainability, taxation and economic regulation, and technical regulation. In each of these areas, the literature is analyzed, and a range of practical solutions are surveyed.

A detailed analysis of past and present mineral policy in Greenland is conducted, which concludes that investment is insufficient, and that the structure of the policy is unsuitable in a number of areas. Based on these conclusions, and on the analysis carried out in the three areas identified, a completely new policy is proposed. This proposal includes both a detailed part dealing with the direct management issues relevant to the drafting of a new mining law, and a more general discussion of the wider management issues, including management of mineral rent under the special revenue sharing principle between Greenland and Denmark, as well as employment and town-site development.

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LIST OF ACRONYMS AND THEIR MEANING

AGIP	The Italian State Petroleum Company
AHSTF	The Alberta Heritage Savings Trust Fund
APF	The Alaska Permanent Fund
ARCO	Atlantic Richfield Corporation
A/S	Aktieselskab (Corporation or Public Limited Company)
GGU	Grønlands Geologiske Undersøgelse (Geological Survey of Greenland)
GM	Grønlands Miljøundersøgelser (Greenland Environmental Research Institute)
HRA	Home Rule Authority (Greenland)
KANUMAS	Kalaallit Nunaat Marine Seismic Programme (Kalaallit Nunaat is Greenland)
MDR	Mineral Development Review (British Columbia)
MRA	Mineral Resources Administration
PRT	Pure Rent Tax
RRT	Resource Rent Tax

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1

INTRODUCTION

In this chapter I will present very briefly the issues related to mining policy in Greenland and the background for the research presented here. In addition, I will sketch previous research on mineral policy in Greenland and describe briefly the structure of the dissertation, the analytical approach adopted in the following chapters and the terminology used throughout the thesis and the areas where most emphasis has been placed.

MINERAL RESOURCES AND THE GREENLAND ECONOMY - A RATIONALE FOR RESEARCH

The Danish territory of Greenland, with its extensive system of local government operating largely without interference from the Government of Denmark, has experienced deepening economic problems since 1988. The causes of this state of affairs are many and complex. However, economic and resource management policies combined with unforseeable changes in the natural location of fish stocks have played significant roles.

Whereas marine resources have been part of life in Greenland from prehistoric times, minerals have only gained prominence as the industrial era was well under way, starting with the mining of the cryolite deposit at Ivvittut from around 1860 onwards. Both this and the other

mines operated in Greenland were essentially the result of surface discoveries in convenient locations.

Attitudes to mineral development in Greenland have been hesitant since the introduction of Home Rule in 1979. The primary reason for this is probably that control over resources and resource revenues is shared equally with Denmark. Conflicts between Greenland and Denmark over leasing of off-shore areas for petroleum exploration in the early 1970's, over uranium exploration in the late 1970's, and over the sharing of mineral revenues have also contributed to this uncertain state of affairs. However, the closure of Greenland's remaining mine, the Black Angel, in 1990 and the onset of a severe economic crisis in 1989-90 led political leaders in Greenland to re-appraise past attitudes towards mineral resources and hope for rapid mineral development. The result was new mineral legislation and efforts to market Greenland as a mineral exploration investment target.

The contents of past and present policies will be examined in much greater detail in subsequent chapters but the main conclusion regarding the policy changes introduced in the 1991 Mineral Law was clear: they constituted a considerable improvement. Early in the present research project, attention was concentrated on the relationship between mineral investors and government. The first issue of concern was one of property rights protection in the sense that investors faced a rather low degree of security of tenure. The second was one of rent capture policies and taxation of mining operations. Under the policy prior to 1991, full tenure was closely linked to rent capture through use of options for state participation in mineral projects. These issues were in part resolved by new legislation in 1991. However, although this mineral policy reform reduced the potential problems in the areas of mineral tenure and taxation of rents, it did not deal with a number of important issues.

The present project, which was initiated before the 1991 policy reform began, on the working hypothesis that mineral policy in Greenland as conducted until then, was inadequate and in need of change. As the project proceeded concurrently with the changes resulting from the 1991 policy reform, the hypothesis was gradually modified. The revised hypothesis is based

on a distinction between four major issues, policy objectives, taxation and rent capture methods, regulation of mineral activities, and economic consequences of mineral operations and their management. It is the principal hypothesis that each of these four areas must be analyzed comprehensively before a complete mineral policy can be developed and put in place. The following sections defines each of these areas in more detail.

Policy objectives

In the documentation supporting the 1991 policy reform some limited quantitative goals are set out along with general remarks about the need for and possibilities of economic development associated with minerals, both petroleum and hard-rock. However, while geological reality ultimately determines the success or failure of any mineral policy, it is important that major reforms are based on a set of realistic and internally consistent goals.

In the present case four groups of goals invite further analysis. First are the operational goals already mentioned. These are, of course, open to discussion as to their underlying motivation (tax income, employment, etc.). Second is the organizational framework in terms of jurisdictional responsibility and power. This group is particularly interesting given the curious and complicated organizational structure in the management of mineral policy in Greenland and the possibility of it changing soon[1]. The third group of policy issues is the extent of government involvement and public perceptions of how minerals are managed (mainly to "sell" the most optimal policy to the voters, even if it conflicts with popular opinion). The fourth and final group concerns the relationship between government and investors in mineral projects. The nature of this relationship has extensive implications for the design of any element of policy.

[1] There is an apparent change of policy underway in the Danish government, which seems disposed to release control over these resources to local governments. This has already happened with the resources of the Faeroe Islands, the other Danish territory in the North Atlantic. The implications of this change have yet to be assessed. The change may also be reversed following the recent (January 1993) change in Government in Denmark, from a center-right coalition to a center-left coalition.

Rent capture, mineral taxation and economic management of mining industry

The second major area dealt with is rent capture policies and other forms of economic management. The net profits from mineral production are an important contributing factor in all government decisions on mineral policy. In relation to the analysis of present policies and the proposal for a future mineral policy, the structure and impact of a tax on mineral projects is of central importance. The question of mineral taxation is important both in relation to the promotion of Greenland as an investment target, and in relation to the rest of the Greenlandic economy. The other aspects of economic management are primarily related to the economic aspects of exploration and environmental regulation

Direct regulation

Direct regulation of mineral operations, as opposed to economic regulation and taxation, covers the four distinct phases of mineral activity, exploration, development, production and reclamation/abandonment. The 1991 Mineral Law for Greenland and its accompanying regulations partially deal with three phases in a "traditional" manner. The provisions range from regulation of the exploration process in terms of what can and cannot be done, over the requirement that development plans and environmental impact assessments be submitted and approved, to the provision of funds for site reclamation at the end of mineral operations.

The primary interest in this area is to determine when such traditional approaches are ideal, and when they are not. At the same time it is interesting to examine the requirement in current legislation, that mineral operations be conducted according to "good mining practice".

Economic consequences of mineral operations and their management

Finally there are the economic consequences of mineral production on the economy of Greenland. These can be divided in different ways depending on the observers point of view, but ulti-

mately they derive from the net value of the minerals (often also referred to as the mineral rent). The economic effects thus depend on how that part of rents which accrues to Greenland, through payments to local factors of production or through tax payments, are managed.

PREVIOUS RESEARCH

Only one major research effort has looked specifically at mineral policy in Greenland. This project was carried out in 1982-84 by Finn Breinholt Larsen, Karen Marie Pagh Nielsen and Jerome D. Davis at the Department of Political Science at Aarhus University, Denmark. The resulting report "Offentlig styring af olie-gasaktiviteter i Grønland ("Public management of oil and gas activities in Greenland") was published in May 1984 (Davis and others 1984). The report was, to some extent, related to the expected petroleum exploration in Central East Greenland, which was much discussed in the early 1980's.

The report deals with issues related to the possible consequences of oil and natural gas development and examines two major issues. The first is concerned with the extent of Greenlanders political influence on mineral policies, and the second deals with taxation and economic issues related to exploration and production agreements (contracts). The report discusses various organizational forms (ranging from purely private exploration and production to a situation where a state company fully controls exploration and production), managerial resources available in Greenland to deal with mineral issues, and possible fiscal income streams accruing to Greenland. The report includes some very simplified and static calculations using different tax structures and hypothetical costs. The emphasis in the report by Davis and co-workers is exclusively on oil and natural gas and there are few references to metallic minerals or other non-petroleum resources. This provides an added reason for the present effort which concentrates mainly on non-petroleum minerals.

Studies of mineral policy design and implementation have appeared from time to time. These studies have primarily been concerned with taxation and rent capture issues (Garnaut and

Ross 1983; Walrond and Kumar 1986) and with mining in developing countries generally (Bosson and Varon 1977). Country-specific studies have covered Bolivia (Gillis 1978), Indonesia (Gillis 1980) and Papua New Guinea (Garnaut and Ross 1983). Much related research on more narrowly defined issues has also appeared. The chapters in part two examine the literature in these and related areas in considerable detail.

Research on Greenland in non-mining areas has venerable traditions dating from the early nineteenth century onwards and is extremely wide-ranging. Geology has been covered by a separate geological survey originating in the work of Lauge Koch, who led the geological mapping of almost the entire East Greenland Caledonian orogen. The work of the survey is recognized internationally as being of the highest quality. In the area of social science the recent contribution by Mark Nuttall (1992) must be singled out, as must the forthcoming work on the Greenland fisheries sector by Graham Poole (Poole 1993). The structure of the Greenland economy has been extensively analyzed by Lyck (1986) as discussed further in chapter 2.

ANALYTICAL APPROACH AND STRUCTURE OF THE DISSERTATION

The present dissertation consists of 10 chapters. The first chapter following this introduction is completely descriptive and presents a background picture of Greenland. The following three chapters examine the literature on mineral development and economics and establish a theoretical framework. Chapter three examines and synthesizes the literature on mineral based development and on the sustainability issues related to mineral exploitation. Similarly, chapter four deals with the different approaches to mineral rent taxation, and with a number of other mineral resource management problems closely related to the quantity of mineral rent subject to taxation. The fifth chapter departs from the strong binding to academic literature and deals with the more technical aspects of mineral regulation. Based on mineral and related legislation in a number of jurisdictions, the analysis is founded on two theoretical requirements. These are that property rights are necessary for markets to function, and that externalities must be regulated.

To set the stage for the central element in the present investigation, chapter six is an analysis of the history of mineral activities in Greenland. The purpose of this chapter is to provide information on the mines which have operated, as well as on the other mineral activities which have occurred in Greenland. In itself the analysis is primarily descriptive.

However, the events described have a parallel in the conduct of government policy, from the date of the very first cryolite concession to the present Mining Law. Chapter seven presents a detailed analysis of these policies and argues that, despite the recent changes in Greenland's mineral policy more change is urgently required. Following these conclusions, chapter eight develops an alternative to the present mineral policy in Greenland, but only as it refers to metallic or "hard-rock" minerals. Petroleum is left for separate consideration and falls outside the analysis from chapter eight onwards.

The final chapter in the main body of the text takes up some of the issues related to the impacts of mineral development. This is done in chapter 9 by examining three case studies of mines in the Arctic. These are followed by an analysis of one of the approaches used in Canada to derive local benefits from mining projects. Rounding of the treatment of mineral impacts is a section dealing with specific methods of capital accumulation as adopted in two North American jurisdictions. Based on these methods a specific proposal for a capital accumulation mechanism for Greenland is presented.

In terms of analytical approach the structure is straightforward. The first chapters (3-5) are used to establish a framework for analyzing the case of mineral policy in Greenland. This framework is based on existing theory on mineral resource economics and management, and on experiences in implementing mineral policies, some of which are based on immediately recognizable theories. The analysis of specifically Greenlandic conditions in chapters 6 and 7 is based on the insights gained in the preceding chapters, with the principal part of the analysis falling in chapter 7. This also applies to the second part of chapter 9, while first part of this chapter is more self-contained.

The approach used throughout this thesis is based on "results" of mineral activities, measured in terms of mineral rent, government revenues and employment, and the means with which these results can be influenced. The alternative is to place more emphasis on the "processes" leading to the "results". However, to constrain the analysis within the appropriate structure of a thesis it is necessary to focus the analysis more than possible if the "system" was examined. As a result I have chosen to emphasize the results over the multitude of different processes involved in any process of policymaking.

The analysis of specific Greenlandic conditions based on the exposition of economic theory and mineral law procedure occurs primarily within a traditional neoclassical economics framework. However, while this involves a number of different models, these are not specified individually.

The analysis leads to a number of conclusions concerning the present mineral policy for Greenland. These conclusions then leads to the proposal for a complete mineral policy for Greenland which is based on the theoretical exposition in chapters 3-5 and the specific conditions in Greenland, as analyzed in chapters six and seven. To illustrate the potential impacts and problems of mineral development in polar regions three specific cases, as well as related Canadian practices, are examined. This approach is less general than elsewhere but its strength is that it focuses attention on a number of important issues.

A NOTE ON TERMINOLOGY AND EMPHASIS

Minerals are the subject of this dissertation. However, the term may be ambiguous since it is commonly used to describe both "hard-rock" or metallic mineral resources and "any naturally formed chemical element or compound having a definite chemical composition and, usually, a characteristic crystal form" (Gary and others 1974). To confuse matters further, many social scientists, particularly economists, include coal, oil, natural gas, and sometimes water, as minerals.

In an attempt to be consistent throughout the term "mineral" is used in the economist's sense of a valuable non-renewable resource. For production of these unspecified minerals the expression "extraction" is used. When the matter at hand is specifically related to hard-rock or metallic minerals the terms "mining" and "mine" will be used. For consistency the term "petroleum" will be used to describe oil and natural gas. This is in preference to the more impractical "hydrocarbons".

With respect to the Mineral Law for Greenland, three terms occur frequently and have special importance. In direct translation they are "preliminary investigation permission", "exploration permission" and "production permission". It is tempting to translate these terms to something less tongue-twisting. However, they are retained on the grounds that the use of this terminology reflects the attitude to mineral development which is entrenched in the administration of Greenland's mineral resources.

This also brings us to the main emphasis in the succeeding pages, mines and mining as opposed to oil production which was the main focus of the contribution by Davis and co-workers. This choice of emphasis is primarily based on a technological consideration. Mining in the Arctic is by now a well accepted possibility, as witnessed by the record of the mines at Nanisivik, Maarmorilik, Lupin, Red Dog and the Polaris operation on Cornwallis Island[2]. Oil and gas production in the Arctic is taking place in both Alaska, Russia, and the Canadian Arctic. Conditions in those parts are, however, far from comparable to those in the off-shore shelf areas of Greenland, which are characterized by massive sea-ice movement. Technologies for drilling and production under such conditions are still in their infancy and other exploration techniques are only partially developed, even though some off-shore seismic work has been carried out in areas off East Greenland with heavy drifting sea-ice during the past two years (see e.g. MRA 1993).

[2] A number of important mines in the Arctic areas of the former Soviet Union are known, the most famous being the nickel and copper mines in the Norilsk area in Siberia. These are important indicators of the technical feasibility of operating mines in the Arctic, but they operate under economic conditions not comparable to the other mines mentioned. Furthermore, much information concerning these mines is still classified information in Russia (Lars Lund, personal communication, 1993)

Finally, there is the terms "the Realm", and "unity of the Realm". These refer to the complete entity known as the Kingdom of Denmark or the state of Denmark. The "Realm" is defined in the Danish Constitution to be Denmark, the Faroe Islands and Greenland.

On a concluding note it must be emphasized that the following chapters are based on a number of implicit assumptions. The first is that mineral policy, and every other economic policy, is composed of the same basic elements everywhere, regardless of whether it is applied in Greenland or in the wilds of Amazonia.

The second assumption is that property rights issues on the international level are clear. This assumption may not be correct in the case of Greenland (where control over non-renewable resources has been a major source of disagreement between Greenland and Denmark) but the assumption is made in order to address the more practical problems of encouraging a mineral industry.

The third assumption or constraint is that the following discussion can be conducted in terms which are mainly economic. There are clearly a number of important political and cultural issues related to mineral policy, but these are too large to include here.

2

AN INTRODUCTION TO GREENLAND

This chapter gives a brief overview of Greenland in terms of geography, history, political organization, economic structure and development. It will not be exhaustive on any of these matters and some of the information presented will be examined in more detailed discussions at later stages of this study.

GEOGRAPHY

Physical features

The area of Greenland is very large, 2,175,600 km^2, of which 1,833,900 km^2 or 84% are covered by ice. The ice-free areas form a zone of variable width along the coast, although the ice-cap reaches the sea in some places.

The most northerly point is Kap Morris Jessup, at 83°39' N, only 740 km away from the geographical North Pole, while Kap Farvel 2,670 km to the south has approximately the same latitude as Oslo, Stockholm or St. Petersburg. The ice-free coastal zone is characterized by an ice-cap which, 1 million years ago, extended beyond the present coastline and into

the shelf areas now covered by the sea, and by geological terrains of many different origins and ages.

The ice-cap has a thickness of up to 3,500 m. and its highest point is at an altitude of 3,200 m. (Berthelsen and others 1989). Considerable parts of the ice-cap rest on a basement which is up to 300 m. below sea level. The depression is probably a result of isostatic compensation, a process by which the total thickness of the earth's crust (including ice) at a given point determines the position of the crust in relation to the mantle beneath.

The continental shelf around Greenland varies in width from the very narrow around Kap Farvel to the extremely wide on the shelf off North Greenland. Beyond the shelf, the ocean floor reaches depths of 4000 m in the southern part of the Labrador Sea. To the east, the North Atlantic has a depth of around 3000 m., while the Arctic Ocean North of Greenland varies in depth from shallow (less than 200 m.) to more than 4000 m.

The sea-currents around the island are dominated by the East Greenland current which moves sea-ice from the Arctic Ocean down along the Eastern coast to Kap Farvel, whereupon the Irminger current (a branch of the Gulf current) then moves the ice North along the West coast. As the Gulf current is warmer, the ice usually melts and disintegrates before it reaches the latitude of Nuuk (Godthåb). Between Paamiut (Frederikshåb) and Sisimiut (Holsteinsborg) sea ice is seldom a problem at any time, while further North ice formation again becomes a problem for shipping (Berthelsen and others 1989).

Whilst Greenland is generally regarded as having an "Arctic" climate, this covers enormous climatic variability. Apart from latitude, the climate is mainly influenced by the ice-cap and the sea-currents around the island. Winter is long and dark, while average temperatures during the brief summer does not exceed 10°C. Extensive permafrost, absence of trees, and generally low precipitation all contribute to the "Arctic" character of Greenland's climate. However, in the South-west, where the climate is influenced by the Irminger current, conifer plantations and birch trees can exist, and sheep- and reindeer-herding is carried on.

The vegetation cover in Greenland ranges from sparse to non-existent. Four vegetation zones are commonly distinguished:

1. The high Arctic: arctic heath, snow beds and polar desert;
2. Dry inland low-arctic: dwarf-scrub heath;
3. Humid coastal low-arctic: herb slopes, willow thickets and crowberries;
4. Northern boreal birch: only in the inner fjords in the southernmost part.

Few species of terrestrial animals can survive in the harsh arctic environment. Those which have managed to adapt successfully include polar bear, polar fox, musk ox, caribou, and snow hare. Sea animals, on the other hand, abound in the waters around Greenland, including seals of many varieties, walrus and several whale species. For the Greenlandic fishing industry cod, Greenland halibut, redfish, and shrimp are the most important species, with shrimp dominating in economic importance (Poole 1992).

Geology

Greenland consists of a number of geological terrains of widely different character and ages (see figure 2.1). The oldest part is the Archean block in the southern part of Greenland, which ranges in age from 3,750 m.y. to 2,500 m.y. This block contains, in the Godthåbsfjord-Isua area, some of the oldest rocks on earth (Moorbath and others 1973). All of this block has experienced prolonged metamorphism (structural, mineralogical and chemical modification processes occurring deep in the crust of the earth), and repeated deformation up until around 2600 m.y. ago (Bridgewater and others 1976).

The Nagssugtoqidian Mobile Belt is a 300 km wide zone north of the Archean block which consists mainly of Archean gneiss (a quartz-feldspar rock with a linear fabric). The oldest rocks have been dated at 2,860 m.y. (Escher and others 1976), and major deformation took place around 1,700-1,800 m.y. ago. North of this mobile belt follows another called the Rinkian Mobile Belt, which consists of rocks that are probably of similar age as the

Nagssugtoqidian rocks, and were deformed at a similar time 1,680-1,870 m.y. (Escher and Pulvertaft 1976). Rinkian terrains are distinguished from the Nagssugtoqidian by a marked difference in tectonic style.

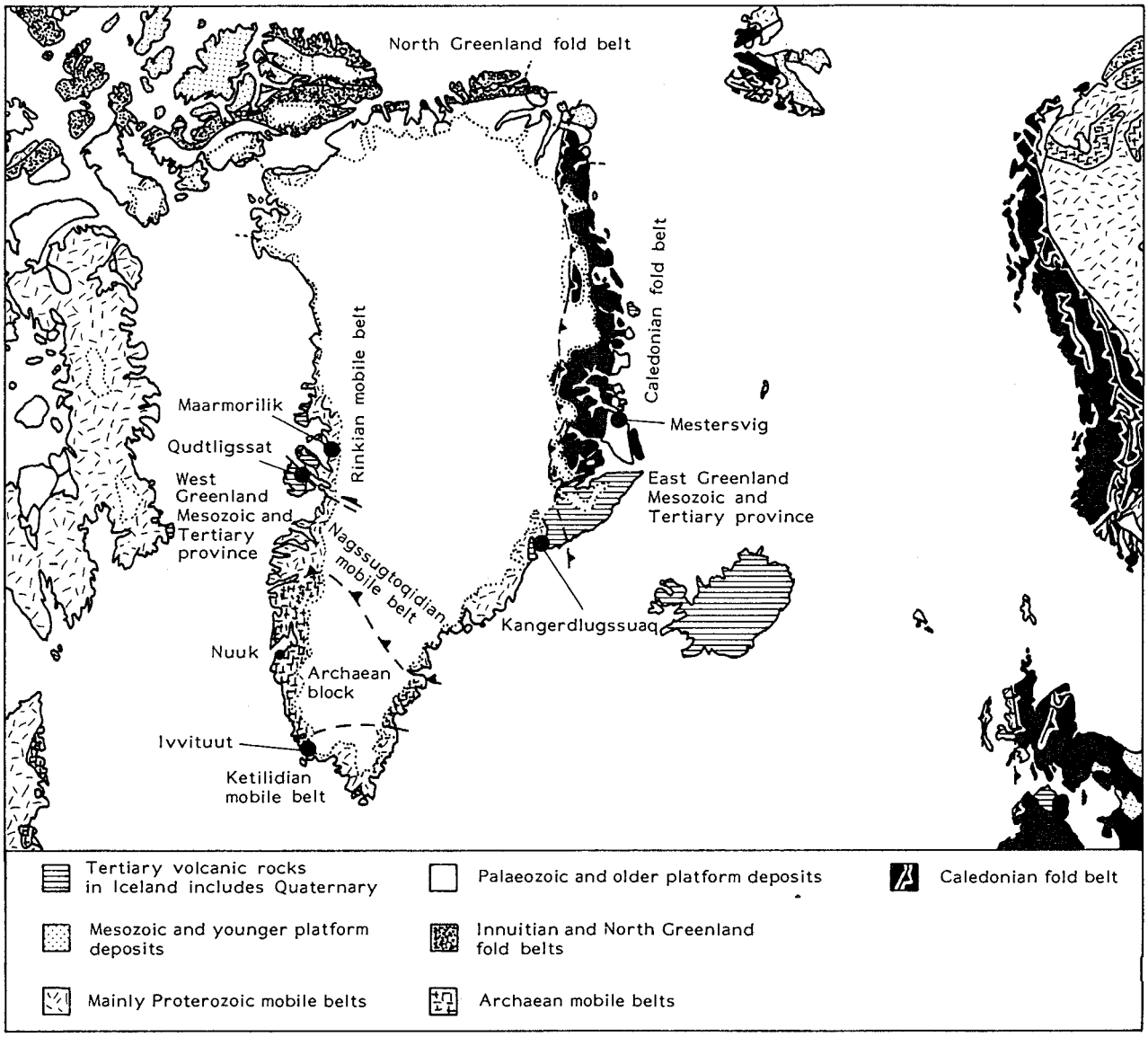

Figure 2.1. Major geological terrains in Greenland (modified from Escher and Watt, 1976)

Located South of the Archean block is the Ketilidian Mobile Belt, which consists of a basement of age 2,600 m.y. and, laid down on top of that, sediments and volcanic rocks that were subsequently deformed and metamorphosed 1,700-1,800 m.y. ago (Allart 1976). Into this mobile Belt the alkaline igneous rocks (i.e. high in Na and K) of the Gardar period,

dated at 1,130 to 1,330 m.y. (Emeleus and Upton 1976), were intruded. In addition to these main Precambrian terrains, rocks of Precambrian age occur as basement for younger rocks in Central East Greenland and in North Greenland.

These younger rocks can be divided into two major fold belts and several areas of supracrustal deposits. The fold-belts are the Caledonian in East Greenland and the North Greenland belt. The former was formed around 320-455 m.y ago, while the latter followed at the end of the same period. It should be noted that though adjacent, the two belts are separated in time and were probably caused by different tectonic events. The Caledonian orogenic event can be explained as a collision between a plate containing Greenland, and perhaps parts of the North American continent, with a plate containing much of Scandinavia and Northern Europe (Henriksen and Higgins 1976). In the case of the North Greenland fold belt only the Greenlandic side is identifiable with any certainty (Dawes 1976).

Rocks largely unaffected by deformation and metamorphism occur in several places. In North Greenland some sediments south of the North Greenland Fold Belt were not affected by this folding, while to the east new sediments were deposited after the folding event. Following the Caledonian folding event, detritus from this belt were deposited in thick sequences along the eastern margin of Greenland. In West Greenland, a large basin of sedimentary rocks evolved in the period of approximately 75 m.y. to 55 m.y. ago, of which the Nugssuaq-Disko area is the smaller, on-shore part, the remainder being the extensive West-Greenland basin which extends along the entire Western margin of the island (Henderson 1976). The most recent major geological events were the extrusion of vast quantities of basalt in both West and East Greenland. These events are thought to be related to the initiation of sea-floor spreading and the formation of Baffin Bay and the Labrador Sea and the North Atlantic, respectively (Clarke and Pedersen 1976; Deer 1976).

The various terrains noted above have a widely different potential for the discovery of viable mineral deposits. This is partly indicated by the uneven distribution of known deposits and occurrences, and also indicated by the variable interest accorded different parts of

Greenland by exploration managers. The famous cryolite deposit in Ivvituut represents the only mined deposit in the Gardar igneous province, while the Black Angel Lead-Zinc mine is located in metamorphosed limestones of the Rinkian Mobile Belt. The formation of the Lead-Zinc deposit at Mestersvig was related to the much more recent events in connection post-orogenic tensional tectonics in the upper Carboniferous, while the formation of the large, sub-economic molybdenum deposit called Malmbjerget (Ore mountain) was closely related to the final opening of the North Atlantic Ocean (Harpøth and others 1986). Currently, most exploration activity is concentrated in four types of terrain. The greenstones of the Ketilidian Mobile Belt in South Greenland are being investigated for gold, as is the famous Tertiary Skaergard layered basic intrusion in Central East Greenland. In central West Greenland the basic volcanic rocks of Tertiary age are explored for massive copper-nickel sulfide deposits of Norilsk type, while in the extreme North East, a remarkable discovery of sediment-hosted lead-zinc sulfide showing is attracting considerable interest.

Population, settlements, and towns[3]

The total population of Greenland as of January 1st 1991 numbered 55,533 persons, of which 8,842 were born outside Greenland. This small population lives in towns or settlements and, to a lesser extent, on scientific stations and military bases.

In this century population growth has been rapid. Since 1901 the total population has increased from a mere 12,000 to the present 55,000, with growth being particularly rapid from 1950 to 1970. After 1970 population growth slowed, and now seems to have stopped (figure 2.2). While it is important to distinguish between persons born in Greenland and persons staying temporarily in Greenland (e.g. Danish civil servants working in Greenland), it

[3] This section and the next relies heavily on data in the Yearbook "Greenland" published annually by the Danish Ministry for Greenland and, from 1988 onwards, by the Greenland Home Rule Authority.

is clear that the Greenlandic-born[4] population have grown significantly, whereas the Danish-born population seems to be declining slightly in the late 1980s and early 1990s.

In recent decades, the demography of the Greenlandic population has changed markedly. The population living in smaller settlements has declined, in absolute terms by 1314 persons over the period 1970-1990. In relative terms, the decline is even more remarkable, changing from 28% of persons born in Greenland in 1970, to 21% in 1990. The less rapid decline in settlement population after 1980 partly reflects Home Rule policies which sought to slow the depopulation of smaller settlements.

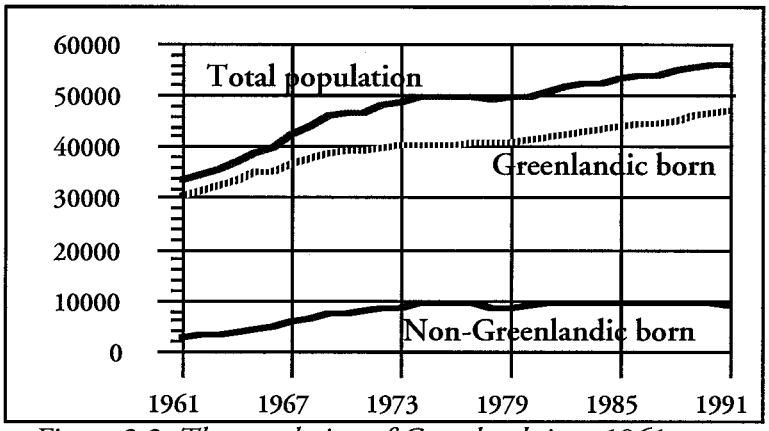

Figure 2.2. The population of Greenland since 1961 (based on data from Grønland Årbog, 1990).

The strong population growth is also reflected in figure 2.3., which shows the age and sex distribution of the Greenland population. Danish civil servants and migrant workers appear as a clearly defined, predominantly male group ranging in age from 20 to 54 years. The Greenlandic population is comparatively young (38% is 20 years or younger compared to 26% in Denmark) and Greenland has not yet completed the demographic transition[5]. However, the life expectancy is markedly lower in Greenland (58.5 years for males and 66.0 years for females) than in Denmark (males 71.5 years, females 77.5 years).

[4] The notion of birthplace defining ethnic origin is misleading. Figures from a 1901 census show that at the time some 46% of the total population of Greenland was not of pure Inuit decent (Barford 1985).

[5] This refers to the time when a decline in mortality is matched by a corresponding decline in fertility (Todaro 1989)

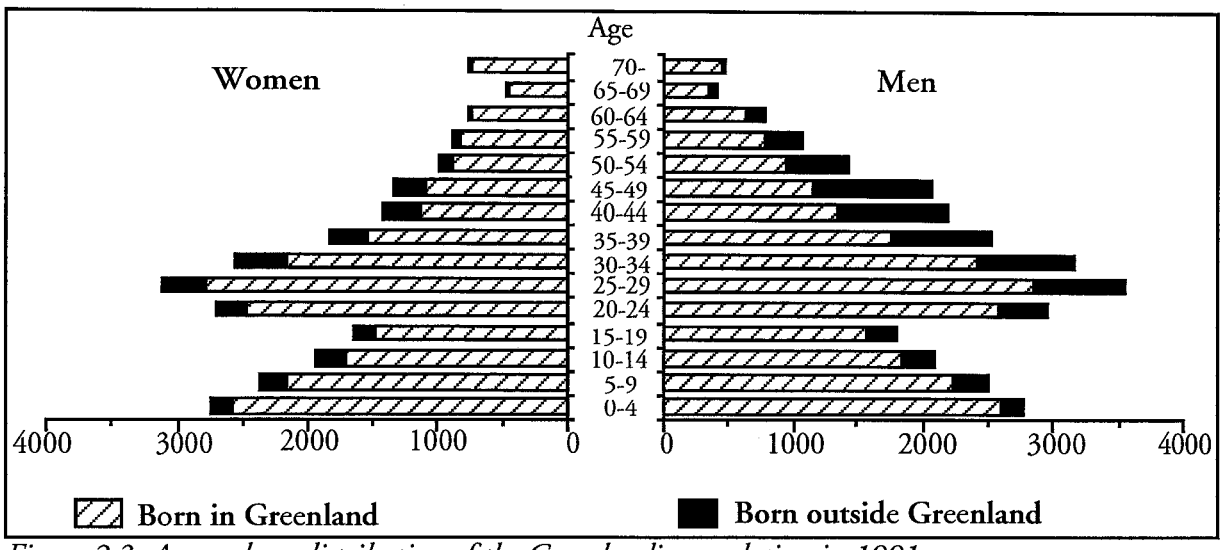

Figure 2.3. Age and sex distribution of the Greenlandic population in 1991.

Settlements range in size from just a few persons to several hundred. The number of settlements declined slowly since 1980, in line with the stabilization in settlement population. The largest town is Nuuk (also the capital of Greenland) with 12,181 inhabitants, and the smallest is Ivittuut, where 211 live. Other important towns are Qaqortoq (Julianehåb), Paamiut (Frederikshåb, Maniitsoq (Sukkertoppen), Aasiaat (Egedesminde), and Ilulissat (Jakobshavn). Towns and municipalities are shown in figure 2.4.

Transport and communications

Climatic and topographic conditions dictate the structure of Greenland's transport and communications infrastructure. Roads exist only within towns and all other transport must use air or sea. Outside the towns, dog sleds and skidoos are used. Regular air links with Denmark, Iceland and Canada are supplemented by freight transport by sea, primarily to and from Denmark. Telecommunications are modern and reach all but the smallest and most remote settlements.

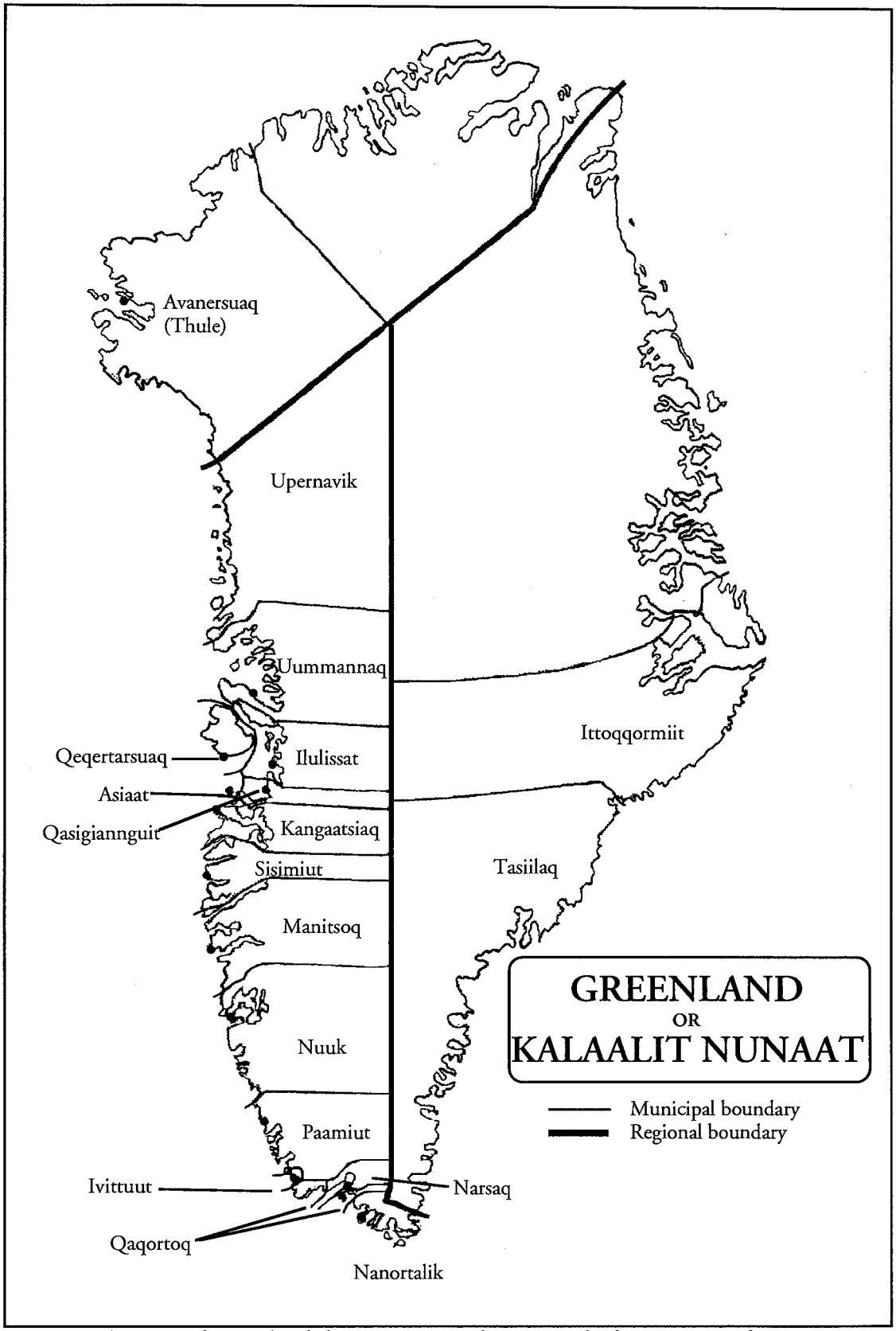

Figure 2.4. Map of Greenland showing principal towns and administrative divisions.

HISTORY[6]

The history of Greenland can be divided into 5 distinct phases. The prehistory ranges from the earliest known settlers who migrated from the Western Arctic around 2500 years BC, to the almost simultaneous arrival of eskimos of the Thule culture in the North and norse Vikings in the South. The colonial phase began in 1721 with the arrival of Hans Egede, a Danish Lutheran missionary, and lasted until just after the Second World War. The fourth phase can be called the assimilation phase after the efforts to make Greenland part of the Danish nation. The fifth and present phase began in 1979 with the introduction of Home Rule in Greenland.

The earliest settlements

The different pre-European invasions and settlements of Greenland, which originated in the Eastern Canadian Arctic, are summarized briefly in table 2.1.

TABLE 2.1. THE EARLIEST SETTLEMENTS IN GREENLAND

Period (approximately)	Name of settlement culture
2500-2000 BC	Independence I
2500-1000 BC	Sarqaq
1000-700 BC	Independence II
200-0 BC	Dorset I
800-1000	Dorset II
900-	Thule
982-1400	Norse Vikings

Sources: Gad (1984; Lidegaard (1991)

Danish Colonization

During the 15th and 16th centuries visits by European whalers (Dutch, English and Portuguese) and scientific expeditions became increasingly frequent. The whalers came to exploit the plentiful whale stocks in Greenlandic waters. While there, they also traded with the Greenlanders. Iron (for tools) and other goods were given in exchange for whale-blubber, sealskins and ivory.

[6] This section relies heavily on Gad (1984) and Lidegaard (1991)

The whaling went on for 150-200 years, but at the beginning of the 18th century depletion of whale stocks and lower returns to whaling investors led to conflicts between whalers and Greenlanders. These conflicts, as well as the weakening of nominal[7] Danish-Norwegian authority (at the time the two countries were one realm) caused by the extensive foreign activity in Greenland waters, led to the dispatch, in 1721, of a combined trade and missionary expedition led by the clergyman Hans Egede.

Despite setbacks, the colony and the trade with Greenlanders survived (albeit subsidized from Denmark) and developed slowly to cover most of the West coast from Frederikshåb (Paamiut) to Upernavik (see figure 2.4). In 1772, however, the private trading company went bankrupt and the Danish Crown took over the management of the trade and established the Royal Greenland Trading Company (KGH) for the purpose. KGH was provided with a firm regulatory framework in 1782 under which access to Greenland was restricted and special inspectors were appointed to oversee KGH activities and to serve as a combination of law officers and justices of the peace.

The Greenland trade was interrupted by the Napoleonic wars and only became profitable again in 1825. During the 19th century, the KGH monopoly was almost broken up, but was retained for "humanitarian" reasons (to prevent the evils of competition). Instead, payments for the Greenlander's products were increased, with unfortunate results. The purpose of higher prices was to enable Greenlanders to invest in productive improvements, but the result was that the higher incomes were used exclusively for consumption, and many Greenlanders even disposed of essential possessions such as skins used for clothing and similar domestic purposes. The rest of the 19th century was marked by economic and social stagnation.

In 1908 a new law for Greenland was enacted which provided for more local influence in both local and legislative matters. The operation of the KGH was partly separated from the administration of other government business, which was turned over to local councils. At

[7] The island was considered part of Denmark's North Atlantic territory based on the Norse colonization from 982 to around 1400.

the same time, two regional councils were set up which were to be consulted on legislative proposals.

In the first decades of the 20th century, the climate grew slightly warmer and the seal-catch declined, resulting in fundamental changes in the economic structure of Greenland society. The fishery for cod and salmon became increasingly important, but whereas seals had provided almost all the necessities of life, cod did not. The subsistence-hunting primitive society had to be replaced by a much more modern, monetized, economy. To keep pace with these changes, official policy also had to adapt. Whilst the subsistence economy required that the population be as dispersed as possible in order to utilize seal-stocks, the fishing industry required more concentration of the population.

The coastal fishery grew, and Greenland experienced some measure of prosperity. This change was, however, small compared to the outbreak of the second world war and the German occupation of Denmark. A centralized authority was introduced under the leadership of the Danish governor of Greenland, and at the same time the Danish ambassador to the United States negotiated a treaty which allowed the US to build bases in Greenland in return for American recognition of Danish Sovereignty in Greenland. In addition, the US helped replace the supplies which no longer arrived from Denmark.

Postwar development policy

During the Second World War, the emergency administration had worked remarkably well and a return to prewar conditions was difficult. Greenland's staunch support for the allied powers during the war had to be rewarded and at the same time the newly formed United Nations began asking questions about the colonial status of the island. The resulting policy, announced in 1950 (and commonly known as "G50"), proposed a completely new policy for Greenland. The main changes were the partial abolition of the KGH monopoly, concentration of the population in larger centers, a more formalized legal system, separation of church and

schools, new hospitals, and much new housing. A central element in the new policy was that, following initial Danish investment, the economy should be self-sustaining. To complete the reforms and to satisfy the United Nations, Greenland formally became part of the Danish Realm when a constitutional amendment was adopted in 1953, following a referendum in Denmark. No referendum was held in Greenland but the agreement of the non-elected regional councils was obtained.

Development plans G50 and G60

The economic development envisaged in the G50 plan did not materialize, mainly because the private investments in production were much lower than anticipated. The failure of this plan served to illustrate forcefully that equality (in terms of living standards) between Denmark and Greenland was very difficult to achieve, given the much more extreme physical environment, the lack of infrastructure, lower standard of education and differences in culture between Greenland and Denmark. These problems were recognized in the early 1960s, and a modified policy (G60) replaced G50. Danish management, a policy to concentrate the population in larger towns and settlements, and the forced abandonment of smaller settlements as well as the emergence of an intellectual Greenlandic élite led, in the early 1970s, to demands of more Greenlandic influence.

In the resulting negotiations the present Home Rule system (described below) was designed, in some cases (such as the question of mineral resource ownership) only after protracted discussions. The proposals for a Home Rule system involving gradual transfer of responsibility from Danish to Greenlandic authorities were enacted as the Home Rule Law by the Danish Folketing (Parliament) in November 1978 and endorsed by a referendum in Greenland in January 1979. As a result, the new Home Rule system came into force on May 1st 1979 and the gradual transfer of responsibilities to the Home Rule Authority began.

The Home Rule period

Under the Home Rule system the transfer of responsibilities happened much more rapidly than expected (Lyck 1989). The Home Rule Authority has since attempted to stop the de-population of settlements through various subsidized measures. Since 1979 the highly state (i.e. Home Rule) controlled fishing industry, which has been developed since the 1960s, has continued to exist. It never fulfilled the expectations for rapid economic development associated with it. In political terms, the major event since the introduction of Home Rule, was the withdrawal from the European Community (EC), which Greenland had automatically joined in 1973 when Denmark joined. The withdrawal was based on the clear conflict between the principle of self-determination on which the Home Rule system is based, and the fact that fisheries, the single most important element in the Greenland economy was controlled from Brussels (Harhoff 1983). The situation was compounded by suspicions of extensive violations of quotas by EC fishers. Despite the official withdrawal, Greenland has maintained a relationship with the EC, under which Greenland fish products are almost fully exempt from EC tariffs. Special agreements also allow EC fishers to fish in Greenland waters within limited quotas (Martens 1992).

The most interesting aspect of the relationship between Greenland and the EC follows indirectly from the fact that public life and policy in Greenland relies heavily on the procedures followed in Denmark. However, as Denmark becomes increasingly integrated into the economic, monetary and political union of the EC (known as the Maastricht treaty), direct impacts on Greenland are inevitable. The most obvious problem will be the introduction of a common EC currency, but many other impacts can arise from the gradual adaptation of Danish legislation to EC standards (especially in areas where Danish legislation applies in Greenland) (Martens 1992).

Home Rule authorities and jurisdictions

The Greenland Home Rule system consists of a legislature ("Landsting") currently with 27 members and these elect an executive or cabinet ("Landsstyre"), currently consisting of seven members of the legislature. Elections for the legislature are held every four years. The principal areas of Home Rule authority are: Fiscal policies of the Home Rule, organization of Home Rule and local (municipal) government, direct and indirect taxes, the churches (i.e. the Danish state church, which is Lutheran-evangelical in orientation), fishing, hunting, agriculture and herding, land use planning, trade and competition, social welfare, health, labour market, education and culture, state enterprise, public utilities (electricity and water supply), housing, internal transportation, and environmental protection. The areas not transferred to Home Rule include international relations (except a few areas where Greenland is directly affected), defense, monetary policy[8], citizenship, constitutional affairs, criminal law, and laws of persons, family and inheritance, as well as contract law (Foigel 1980). Greenland is divided into 18 administrative districts, each of which is run by a district council and headed by a Mayor. The district authorities are responsible for finance, social services, education and culture, housing and labour affairs.

ECONOMIC DEVELOPMENT IN GREENLAND

The economic development of Greenland is closely related to its history. Here we take the colonization in 1721 as our starting point. Three distinct phases are recognized: colonial subsistence economy, planned economic development after 1945, and the transfer to Home Rule in 1979. The time after this event is treated separately in the subsequent section.

[8] Greenland uses the Danish Krone as currency

Subsistence economy in the colonial period

The traditional way of living in Greenland at the time Hans Egede arrived in 1721 was based on whale and seal and to a lesser extent on caribou and salmon. Intensive activity by European whalers in the 17th and 18th centuries may have contributed to declining whale stocks. The Greenlandic culture, however, successfully adapted to this change by increased specialization in the seal hunt. During the colonial period depletion of whale stocks continued.

From the arrival of Hans Egede in 1721, Greenlanders were employed in new occupations. The first figures shows that, in 1834, 13.8 % of the employed population had non-traditional occupations such as commercial fishing, construction, mining, and administration. Until the 1930s this figure varied between 12 and 19% but from 1945 the share of people in non-traditional occupations jumped to almost 34% (table 2.2). This table also reveals the increasing importance of the fishery from 1911 onwards.

TABLE 2.2. EMPLOYED POPULATION BY OCCUPATION, 1834-1945 (PERCENT)

Year	European occupation	Hunting and sealing	Fishing
1834	13.8	86.2	
1860	17.6	82.4	
1890	12.1	87.9	
1911	13.8	73.0	11.1
1921	18.2	66.5	15.1
1930	16.2	49.0	32.0
1945	33.9	41.6	20.1

Source: Modified from Kjær Sørensen, 1983, pp. 15 and 40.

The Greenlander's production was, to the extent that it was not used by themselves, purchased by the Royal Greenland Trade Company (KGH) as it had been since the establishment of the monopoly in 1772. The Greenlanders used their income to buy a range of consumer goods and food, the latter item becoming increasingly important when the decline in the sealing in the first part of the 20th century reduced the traditional reliance on seals for almost all necessities of life (Kjær Sørensen 1983).

Planned economic development 1950-1979

After the second world war it was clear that a new system of management in Greenland was both expected and much needed. The Greenland people, represented in the two regional councils, was presented, in 1948, with one option: development of Greenland into a modern society (Kjær Sørensen 1983). The resulting policy, G50, which was implemented from the beginning of the 1950s, included a significant increase in the standard of living, which was to be achieved through private investment, mainly in the fishery sector. In addition, the Danish state invested heavily in infrastructure, housing and health care (Lyck 1986).

The G50 policy was, however, flawed in several respects. While it resulted in major investments in housing and infrastructure, it used Danish labour for these projects - so as not to draw Greenlanders away from the occupations on which they were to rely in the future. Thus there was little transfer of skills in the course of the G50 plan. Similarly, the educational policy was based on general educational improvements, rather than the encouragement of an intellectual élite with academic or business-oriented training (Lyck 1986). Most critical to the G50 plan however, was the fact that while the state investments proceeded as planned during the 1950s, the hoped-for private investment in production did not take place.

As the failure of G50 became increasingly evident in the early 1960s a policy review led to a significant change of policy. The fishery was still the main commercial activity, but now the development of this business was financed and managed by the Danish state. An accompanying measure, aimed at providing pools of labour at strategic locations for the fish processing plants, was a policy of concentration and settlement abandonment. At the same time significant saving in the supply of goods for these settlements was used to justify the policy (Kjær Sørensen 1983). In terms of the benefits to the labour employed in the fishery, the wages were linked to both labour productivity and the world-market price for fish products (Lyck 1986). Despite many good intentions the plan was

adversely affected when, in the course of just a few years, the most important species, cod, almost disappeared from Greenlandic waters (Kjær Sørensen 1983).

Transfer of responsibilities to the Home Rule system

As noted, the transfer of responsibility for specific areas was based on the principle that the grant accompanying the transfer should reflect the expenditure level under Danish state management at the time of transfer. At the same time, however, the Home Rule Administration has no subsequent obligation to maintain expenditure in a specific area and can dispose of the grant at its own discretion[9]. The transfer of responsibility proceeded rapidly after 1979, and the final transfer took place in 1992, when health service came under Home Rule management. The effect on public spending resulting from the transfer is reflected in figure 3.1, which shows the current expenditures of the Home Rule Authority, the local councils and the Danish state since 1979.

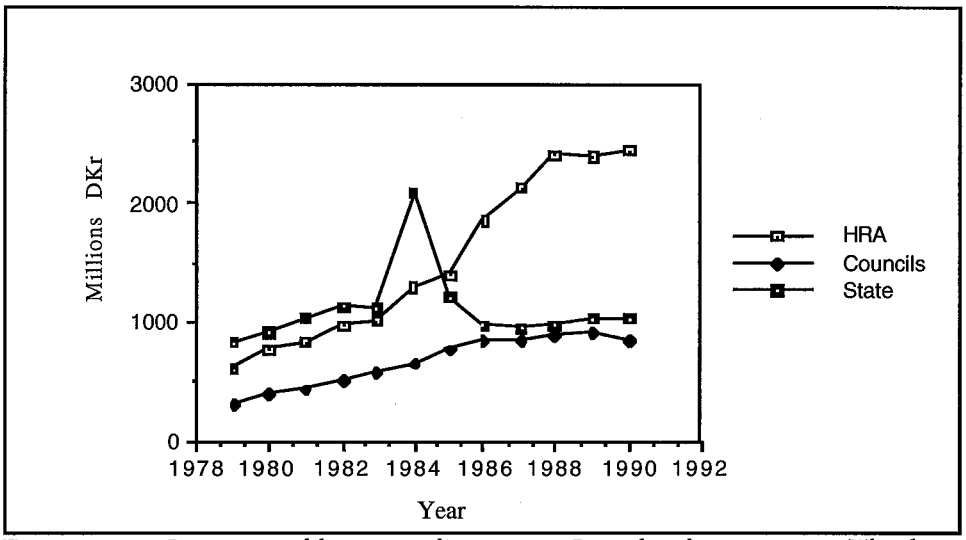

Figure 2.5. Current public expenditures in Greenland, 1979-91. The large jump in spending in 1984 reflects the purchase of two new vessels for fisheries inspection. (compiled from Grønland Årbog 1982-90).

[9] For example, if the HRA took over an area where annual expenditures were 100 million DKr, this sum was added to the net unrequited transfers while the HRA is free to use the funds as it wishes.

The Greenlandic economy under Home Rule management

The Greenlandic economy is small, open and highly dependent on two income-streams. One comes from the fishing industry, and the other from net unrequited transfers from Denmark. In terms of per capita gross domestic product, it resembles a developed country, while by other measures the country is midway between a developing country and a developed country. These characteristics are brought out by the data in table 2.3., which compares Greenland to Chile, Zimbabwe and Denmark.

The Greenland economy has grown in fits and starts since the introduction of Home Rule in 1979, as shown by table 2.4. The good years for growth were 1981 and 1986-88, with quite high increases in per capita gross national income (GNI). On the other hand, 1982, 1984, 1989 and 1990 were dismal, with substantial reductions in income. Employment is strongly seasonal, with the highest proportion being employed in the period June to September. Furthermore it is clear that turnover on the labour market is high[10]

TABLE 2.3. COMPARATIVE DATA SHOWING INDICATORS OF THE STAGE OF DEVELOPMENT FOR GREENLAND AND THREE OTHER COUNTRIES

	Greenland	Chile	Zimbabwe	Denmark
GDP per capita 1985 (Current US$[a])	8,098	1,320	600	11,354
Life expectancy at birth, males (Years)	58.8[b]	68.05	56.52	71.80[c]
Life expectancy at birth, females (Years)	68.1[b]	56.72	60.13	77.60[d]
Infant mortality in 1987 (age<1) per 1000	26.6	18.5	72.1	8.3

Notes:
a. Calculated using an exchange rate of 1 US$ = 10.115 DKr.
b. 1986-90
c. 1986-87
d. 1985-90
Sources: Figures and calculations based upon data taken from The Greenland Home Rule Treasury Department (1988) and United Nations (1988, 1990).

[10] The number of unemployed at the end of a month is generally much lower than the number of people who experience periods of unemployment during the month (Grønlands Årbog, 1990). If unemployment at the end of each month is taken as an indication of the level of unemployment this indicates that people move in and out of jobs rapidly.

TABLE 2.4. GNP AND GNI IN GREENLAND 1980-90 (CURRENT PRICES, 1,000 DKR)

Year	GNP	Disposable GNI[a]	GNP growth (%)[b]	Disposable GNI per capita
1980	2,683	4,395	-	87.5
1981	3,104	4,826	8.2	94.6
1982	3,353	5,499	-5.3	106.4
1983	3,806	5,864	1.2	112.5
1984	3,929	6,303	-4.5	119.7
1985	4,375	6,708	1.8	126.2
1986	4,999	7,182	8.4	134.0
1987	5,875	8,117	14.3	150.0
1988	6,631	8,948	4.9	163.1
1989	7,072	9,283	-0.6	167.7
1990	6,732	9,149	-10.0	164.6
1991	6,568	9,181	-6.7	165.4

a. Disposable GNI includes the net unrequited transfers from Denmark
b. Base year 1980
Source: Grønland Statistiske Kontor, 1991 and Grønland yearbook 1992/93.

Inflation has been moderate since Home Rule was introduced, on average 7.4% annually. However, in the first part of the 1980s the inflation rate was 14.7%, declining later to a record low of 2.9% in 1986-87 (Grønland Årbog, 1990).

Home Rule Administration

The Home Rule Administration is the major public organization in Greenland. In addition to its own administrative activities, the major areas (as measured by current spending) are education (post primary level), social services, transport, housing, and the three Home Rule owned enterprises Greenland Trade/KNI, Nuna-Tek, and Royal Greenland. Greenland Trade/KNI which consists of three subsidiaries responsible for retailing in towns, supply of settlements, postal services and shipping. Nuna-tek is in charge of public utilities including electricity, telecommunications, energy supply, and also some construction and shipyards), while Royal Greenland has production and trade in fish products. In addition the Home Rule Administration transfers large sums to the local councils. The allocation of current spending to the various areas is shown for the past 6 years in table 2.5. The significant increase in spending over the period reflects both the transfer of health care and a change in accounting procedure in 1992.

TABLE 2.5. CURRENT EXPENDITURES OF THE GREENLAND HOME RULE AUTHORITY, 1988-93 (DKR MILLIONS)

Year	1988	1989	1990	1991	1992	1993[1]
Administration	209	230	257	264	265	273
Education & culture	392	422	433	441	482	493
Social services[2]	313	136	151	155	158	204
Transfers to councils	477	722	793	851	879	946
Internal air transport	43	47	52	90	112	141
Home Rule enterprises	402	152	256	164	137	251
Subsidies to businesses	130	226	289	265	243	350
Housing	-	9	-41	-50	-40	-80
Health care	-	-	-	-	539	514
Net interest payments	-	-	54	67	16	14
Other expenses	55	227	27	67	52	75
Total current expenses	2021	2221	2271	2314	2843	3181

1 1993 budget
2 The decline reflects that councils have taken over some social services, hence the increase in transfers.
Source: Annual reports from the Advisory Committee on Greenland's Economy, 1989-93.

Parts of the Home Rule Administration itself and the enterprises directly owned by the Home Rule Administration are characterized by relatively large investment programs. The major areas are housing, Royal Greenland production facilities and Nuna-tek. For the latter, large investments are currently being made in a hydro-electric generating facility in the vicinity of Nuuk (Buksefjorden). The distribution of investment expenditure in the years 1979-84 and 1987-91 are shown in figures 2.6. and 2.7.

The data used in these figures are, however, ambiguous. They do not use the same grouping of expenditures, and the data had to be split into two overall groups. The change in grouping reflects the transition to Home Rule management of important parts of the economy in 1985-86 which led to a change in accounting procedures. Furthermore, the investments quoted are measured in current terms, and an examination of the index for current and capital expenditure by the Home Rule shows that in 1990, current expenses were about 10% above their 1981 level, while investments were 14% below, having declined sharply from an index of 119 in 1989 to 86 in 1990 (Grønland Årbog p. 72, 1990).

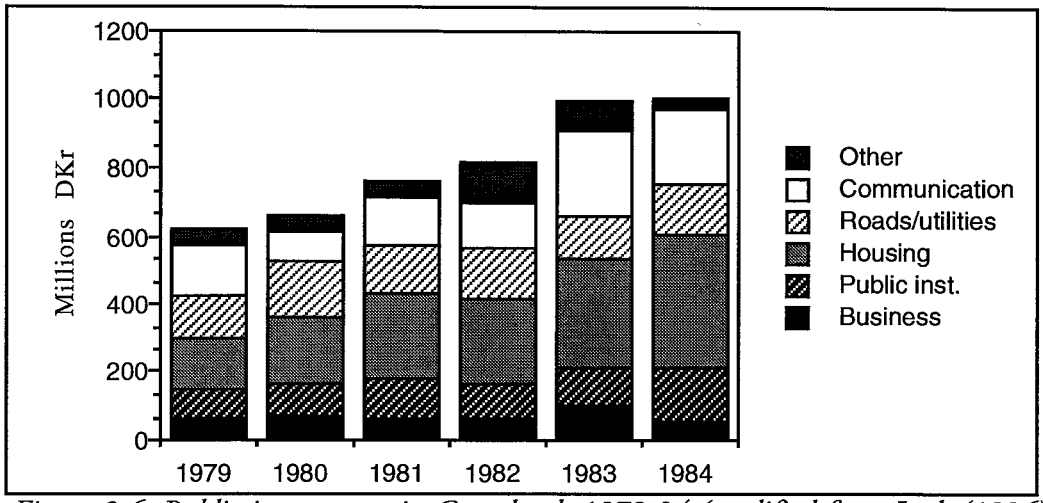

Figure 2.6. Public investments in Greenland, 1979-84 (modified from Lyck (1986), table 6.2).

Municipal councils

The municipal councils in Greenland are primarily responsible for the system of primary schools, a major part of the social service system and for roads, refuse collection, fire brigades, etc. While the councils are major landlords in their own right, they are also responsible for the administration of housing owned by the Home Rule Authority. The major areas of public investment by the local councils is also housing. The activities undertaken by the councils are partly financed through grants from the Home Rule Administration, usually earmarked for specific purposes. In addition, the councils have the power to raise funds through income taxes.

State jurisdictions

The areas retained by Denmark under the Home Rule Act of 1978 include defense, judicial affairs and the legal system, and some activities related to weather forecasting and shipping services. Furthermore, the monetary policy is under Danish control. Until 1992, the health service was also under Danish management and is included in the budget for Danish state expenditure in Greenland. Apart from the net unrequited transfers, health was, with 20% of current expenditures, the largest single area of spending in 1991. For defense,

the major area of expenditure is fisheries inspection (which received 80% of investment expenditures in 1991, for new inspection vessels and helicopters). A special case is exhaustible resources, which are subject to a special joint management system (see chapter 6 & 7).

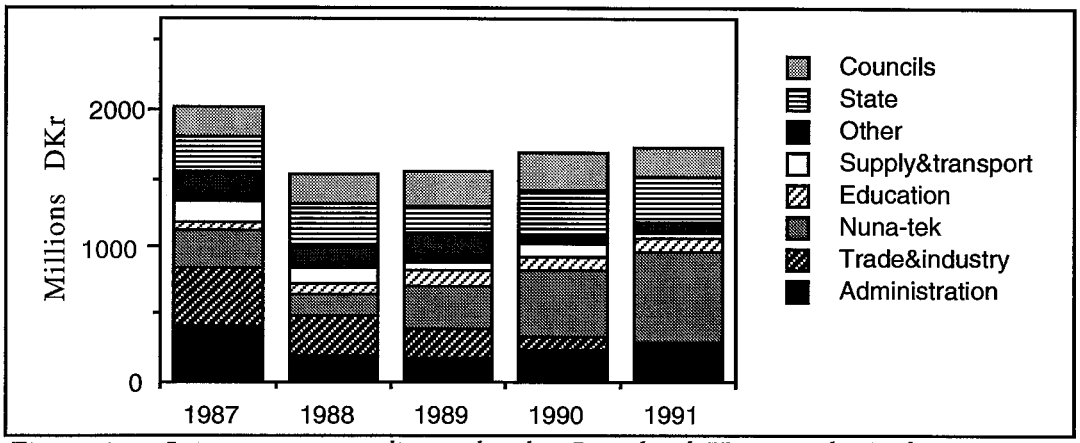

Figure 2.7. Investment expenditures by the Greenland Home Rule Authority 1987-91 (compiled from Newsletters from the Home Rule Directorate of Economy).

Production and trade

Primary production in Greenland relies, especially after the closure of the Black Angel lead-zinc mine at Maarmorilik in 1990, almost exclusively, on fisheries. In 1988 primary production accounted for 21% of national income (including mining, 5.3%). The primary sector employed 10.2% of the workforce in 1987. Manufacturing (i.e. processing of fish) accounted for only 2.8% of income and 9.4% of employment. The secondary sector as a whole generated 23% of income and employed 22.5% of the workforce. The tertiary sector accounted for 58% of income and employed 65% of the workforce. Almost half of the income generated in the tertiary sector (27%) originated in the public sector or by companies wholly owned by the Home Rule Administration, a far higher share than, for example, Denmark, Norway or Sweden. To complete the description it should be noted that 5-10% of the population relies on subsistence hunting and fishing, having only limited contact with the monetized sector (Poole 1990).

The major primary industry, fishing, has been beset by problems. Prior to the mid-1980s, the dominant catch was cod, but this fishery collapsed for reasons believed to be related to climatic and oceanographic changes and possibly overfishing. Instead, increasing emphasis has been placed on the shrimp fishery. This, however, is also having problems, mainly because a significant over-capacity in the shrimp fleet has meant that each vessel will maximize the value of limited quotas by discarding smaller size shrimps which are less valuable (Poole 1992). The problem has been recognized by the Home Rule Administration, and policy has been adjusted to encourage the retirement of older and less efficient vessels. The problem of discarding has not yet been solved (Poole, 1992).

In the secondary sector, construction is by far the most important industry, accounting for 17% of national income in 1988 and 8% of employment (half of which were born outside Greenland) (Grønland Årbog, 1990). Given the extensive involvement of the Home Rule Administration in housing, infrastructure and industry, and the housing policies of the local councils, it is clear that the industry is very sensitive to changes in public investment policy.

The main export commodity is fishing products. Before 1991, minerals also contributed significantly to exports but this ended with the closure of the Black Angel mine at Maarmorilik in 1990. Table 2.7. shows exports (by main categories) and total imports as well as the visible balance of trade for the period 1984-92. The table is based on official statistics and does not take re-export or re-import into account. Estimates by Lyck (1986) for the period 1979-84 indicate that actual data for export and import should be reduced by 5-10%.

The dramatic improvement in the balance of trade from 1987 to 1990 reflects the very tight economic policies pursued by the Home Rule Administration in recent years. From 1991 the visible trade balance has deteriorated severely, for two reasons. One is that the end of mining, but the decline in fish exports is also strong.

TABLE 2.6. EXPORTS, IMPORTS AND GREENLAND'S VISIBLE TRADE BALANCE

	1984	1985	1986	1987	1988	1989	1990	1991	1992
Exports									
Fish products	1064	1431	1706	1973	2067	2381	2331	2075	1900
Mineral concentrates	495	332	281	286	472	565	363	0	0
Other	192	79	91	110	92	110	100	104	107
Total exports	1751	1842	2078	2369	2631	3056	2795	2179	2008
Imports	2836	3140	2912	3471	3495	2915	2756	2609	2737
Visible balance of trade	-1085	-1298	-850	-1101	-864	141	39	-430	-729

Source: Grønland Årbog, 1986 and 1990; Advisory committee on Greenland's economy, 1993.

CONCLUDING REMARKS - ECONOMIC PERFORMANCE AND STRUCTURAL PROBLEMS

The years 1984-85 roughly marks the time when the economic decisions by the Home Rule Authority began to influence the economy. In the years to 1987, fiscal policy was very expansionary, as witnessed by the large increase in the budget deficit of the Home Rule Authority, from being close to balancing in 1983 to a deficit of 497 million DKr in 1987. Whilst this may not sound like a large sum, it was, at around 10% of GDP, large by most standards (Westerlund 1988). 1987 also became a turning point for the economic policy of the Home Rule Authority. Severe cash-flow problems and a large need to borrow brought about much tighter fiscal policies, and the short-term result is reflected in the budget improvement of more than 500 million DKr from 1987 to 1988 (Directorate of 1988). The improvement continued in 1989, when a surplus of 265 million DKr was reported. In 1990 and 1991, budgets were close to balanced (Directorate of 1992), while in 1992 and 1993 surpluses of 16 and 151 million DKr, respectively, were expected (Det rådgivende udvalg vedrørende Grønland økonomi 1993).

The economic tightening imposed in Greenland reflects a temporary improvement and is only a partial solution to the economic problems facing the country. These include the large public debt and the oversized public sector, a range of structural problems in the economy and a primary and manufacturing sector that is heavily dependent on a narrow resource base.

The fact that the Home Rule Authority debt has been rising in recent years has been emphasized by Westerlund (1988) as one of the major constraints on the economic policy

of the Home Rule Authority. First of all, the debt reflects the accumulated deficits of the Home Rule Authority, beginning in 1984. However, the actual debt is larger since the Home Rule Authority has been an active lender for housing and commercial purposes. Though officially loans these are often more in the nature of subsidies and should be reflected in the budget (Westerlund 1988), as will be the case for future budgets (Directorate of Economy, 1991). The budgetary improvements in the period since 1987 has stopped the debt accumulation, but has not reduced it much. To achieve this, the Home Rule budget needs to have a significant surplus (around 1,5 % of national income) for upwards of 10 years (Westerlund 1988). For 1989, the surplus was a good start but in subsequent years slightly less headway has been made with debt reduction. A further problem in relation to the debt problem is related to the combined effects of an absent domestic capital market in Greenland and the currency union with Denmark. This union implies that the two countries have the same currency, and that monetary policies are determined by the Danish Central Bank. Borrowing under these circumstances does not result in either higher interest rates or in exchange rate adjustments as would normally be the case. Thus, the "normal" constraints on government borrowing in the form of rising costs are absent and the debt is more free to grow (Westerlund 1988). A final problem is that debt reduction depends on the rate at which the economy grows. Given the large contraction in the economy shown in table 2.4. it is clear that debt reduction is likely to be slow and tortuous.

A second set of problems that have affected the economy are of a structural nature. First and most obvious is the recurrent need to import labour from outside Greenland, mostly from Denmark (Lyck, 1991). This need is closely related to the inadequate education and training which characterize the Greenlandic labour market. The cost to Greenland results both from underemployment of the resident labour force and the high cost of importing labour.

As noted above, administration takes up many resources (accounting for 26% of national income) and needs to be reduced (Lyck 1991). Much of the problem originates in

the transfer of power to Greenland and the use of Danish civil servants. The result has been the uncritical adoption of many Danish administrative traditions at a very high cost (Westerlund 1988). However, even if less ambitious organizational structures were to be adopted, this would be difficult due to the general lack of appropriately educated Greenlanders.

A third structural problem is the settlement pattern in Greenland. The significant number of smaller settlements in Greenland dates back to a time when a large part of the population was employed in either subsistence hunting and fishing or in limited inshore fishery. The development of off-shore fisheries and the use of larger processing plants requires a larger pool of labour in towns with production facilities. This was recognized in the Danish G60 policy, which sought to concentrate the population in the larger towns. The most dramatic example was the forced abandonment of the Qutdligsat coal-mining town in 1972, where 2,000 people were relocated (5% of the entire Greenland born population), an event which caused much resentment towards Denmark and contributed to the demand for Home Rule (Lyck 1986), even if the mine was known to have been highly inefficient for many years. Maintaining many smaller settlements is, however, very costly and causes significant inefficiencies. The reason for this is partly the way it is done. Rather than giving the settlements a direct subsidy, goods and services are provided at the same price all over Greenland. Given the long distances and extreme conditions, the costs are not reflected in the prices charged. The indirect subsidies help preserve an inefficient situation where economic reality dictates more concentration of the population in the towns. Unfortunately, the fact that housing in the towns are in very short supply indicates that the present settlement pattern cannot be dismantled rapidly. Similarly, a large influx of people to the towns could exacerbate the already precarious social situation in Greenlandic towns.

A fourth structural problem is also related to the settlement/town structure. In many of the smaller towns transport cost (though heavily subsidized) and the limited size of the market essentially prevents competition in some lines of business. There are oppor-

tunities for monopoly behaviour and collusion can easily occur. In the construction sector (where much housing construction is undertaken by the local councils), inefficiencies are further compounded by the subsidies provided by the Home Rule Authority (Martinsen 1992), which remove much of the incentive for the councils to be cost conscious.

3

MINERAL DEVELOPMENT MODELS

Mineral development commonly refers to the economic development associated with the discovery, development and operation of mineral projects. For a country possessing mineral deposits of sufficient quality and size the two main issues related to exploitation of these are the direct and indirect economic effects of exploitation, and the timing and speed with which exploitation occurs. The present chapter first examines the economic implications of mineral exploitation and development based upon it. Second, the issue of sustainability of mineral policies is taken up in relation to the timing and pace of exploitation.

MINERAL DEVELOPMENT MODELS

Traditionally, mineral commodities have been exported from less developed countries in raw form, usually as mineral concentrates or crude petroleum. However, over the past 30 years or so, there has been a slow increase in the share of mineral production processed in developing countries (Johnson and Pintz 1985), although it is difficult to determine whether this has been the result of a greater share of mineral production being located in these coun-

tries, of developing country (LCD) government policies, or if the countries in question posses some comparative advantage in mineral processing.

The trend towards more domestic processing can be analyzed from different perspectives, depending on what mechanisms are thought to be at work. The literature in this area suggests that the two major approaches are related to either "resource based industrialization", or development based on investment of mineral revenues (not necessarily in the mineral sector). There are, however, additional problems related to the production and export of natural resources. First is the fact that the growth of a resource sector can have strong adverse effects on a country's economy as a whole, either through the effects of the "Dutch Disease", as defined below or because increased mineral exports will make countries more dependent on the mining sector. The following sections also examine these issues.

Mineral based industrialization

A policy promoting the processing of primary commodities in their country of origin can include elements of one or more of the following strategies: industrialization, trade integration, and economic-environmental strategy, as noted by Johnson and Pintz (1985).

The industrialization strategy seeks to make use of the comparative advantages of having the primary commodity available in the country. These advantages are transport cost savings, availability of subsidized capital, and low cost energy, as well as cheap labour. In addition to the direct effect of processing the mineral products, this strategy is expected to result in linkage effects whereby the processing of minerals leads to derived demand for goods and services, as well as the use of the processed minerals as inputs in downstream manufacturing.

A trade integration strategy is motivated by the belief that the markets for many of the primary commodities commonly exported by developing countries are monopolistic or oligopolistic (e.g. copper concentrate and bauxite) and by the desire to retain economic rent from minerals in the country which might otherwise be transferred (using transfer pricing mechanisms) to countries with more favourable tax regimes.

The third strategy noted by Johnson and Pintz (1985) involves a "pollution advantage" in the sense that the environment in a developing country may have a larger capacity to absorb pollution, as a result of lower degrees of industrialization. Such countries may also be more willing to tolerate environmental degradation, given the potential economic benefits of doing so.

Despite the emphasis placed on mineral based development, there are, however, several strong reservations about the usefulness of such strategies, regardless of their good intentions. Immediate concerns include higher capital costs of projects in developing countries (canceling out the supposed availability of subsidized capital), significant technological risks, and difficulties in raising the required capital (Johnson and Pintz 1985). The value of these strategies is determined by economic mechanisms, and the assumptions on which the strategies are based.

The first assumption is the idea that processing primary commodities, which are otherwise exported, implies value added to the export goods and further, that this is beneficial to the country. Although this may be the case, the benefit may be smaller than expected or absent. The underlying assumption for promoting processing in the country of origin is that there may be a comparative advantage in doing so. The presence of this advantage depends on a range of circumstances such as factor intensity, costs, transport costs, price of complementary inputs, availability of economies of scale, the existence of external economies, and on processes of technological change (Roemer 1979).

In terms of factor intensity, most resource processing industries have high capital to labour ratios (as do the mines), indicating that developing countries with cheap and abundant labour have no competitive advantage (Balassa 1977). Only at the manufacturing stage does labour become an important input, and give advantage to developing countries (Roemer 1979). The perceived comparative advantage may also be the result of the reduction in transportation cost, as a result of weight reductions during processing of concentrate to metal.

Some savings may be possible on this account (Radetzki 1977), but on the other hand, this may be lost again when the higher cost of handling non-bulk material (e.g. metal bars or ingots) is taken into account. A typical example is the processing of bauxite ore into aluminium metal. Both the bauxite and the intermediate product alumina are bulk materials and easy to handle in large volumes. Once the alumina is smelted into aluminium metal ingots handling is more complicated. Thus, despite the 50% weight reduction at both stages of the process (bauxite to alumina and alumina to aluminium metal), this is generally far less important for the selection of processing location, than is the availability of cheap electricity (Peck 1988; Nappi 1992).

In some cases, transportation cost puts developing countries at a comparative disadvantage. It is, for example, much less expensive to transport elemental sulfur than the end-product for which it is intended, sulfuric acid. Similar disadvantages are found in iron ore and steel, where the transport of large items of steel is much more expensive than moving semi-processed iron ore pellets. In both cases, a large part of the processing and manufacturing will take place close to the end use market. The competitive position of developing countries is also influenced by the availability of complementary inputs. As noted above, in the smelting of alumina to aluminium, energy is the essential input and the location of aluminium smelters is primarily determined by the availability of low cost electricity.

Further determinants of the competitive position of a [developing] country are the existence of scale economies and external economies in many resource processing industries, and processes of technological innovation (Roemer 1979). Scale economies may be difficult to achieve in developing countries for the simple reason that these countries are seldom able to supply inputs (i.e. mineral concentrates) sufficient to feed an optimally scaled processing plant. This problem may be compounded by difficulties in marketing output from large facilities, in markets characterized by strong vertical integration (e.g. the aluminium and petrochemicals markets). External economies, associated with the existence of markets for addi-

tional outputs from processing, are also unlikely to be present in many developing country settings.

Resource based industrialization is often put forward as a means to increase employment in the primary resource producing country. Given the low labour content of most resource extraction and processing, this effect must come through the linkages of the primary sector to other sectors, but even here the prospects for employment are limited (Roemer 1979). Substitution of labour for capital may occur as a result of political pressure on resource companies. Even if resource industries have low labour intensities they may nevertheless have significant effects on the rest of the economy. This is because the resource industry is prepared to pay higher than average wages in order to get the best and most productive workers. In turn this may lead to the classical migration-unemployment situation (Harris and Todaro 1970), where labour will migrate to areas with high unemployment.

In conclusion to the above discussion it is interesting to examine the results obtained from cost comparisons between developing country and US producers of aluminium (Adams and Duroc-Danner 1987). By comparing production costs for a wide range of products in both the member countries of the OECD (Organization for Economic Cooperation and Development) and the developing countries it was shown that, on a simple exchange-rate comparison, developing countries have a significant comparative advantage over US producers, with nominal operating costs which are 72% of those in the US. However, by comparing relative costs, both on US and LDC cost basis, it is demonstrated that in fact US producers have a significant advantage. This indicates that the main reason for the shift in processing of bauxite to aluminium has been the result of exchange-rate effects.

A mineral industry may also produce a number of linkages to other sectors of the economy (Hirschman 1958), either forward or backward. Backward linkages involve the production of inputs used in the mineral industry, ranging from the food and housing consumed by workers, to plant and equipment for the mine and mineral industry. Forward

linkages implies that the output from the mineral industry is used for downstream manufacturing and fabrication. Both types of linkages are potentially important (Radetzki 1982), but their emergence depends on the comparative advantage of the activity in question (which may be artificially created through government policy). The fact that a mineral industry as well as linked industries may create unwanted effects in the economy as a whole is discussed further below.

There is a third type of linkage which is related to the infrastructure commonly established in connection with mineral projects (roads, railways, power and water supplies, schools etc.). It is seldom possible to exclude others from using such facilities, which thus create a positive externality.

The preceding discussion indicates that industrialization could be based upon linkages. It is, however, difficult to find unequivocal examples of this taking place. Furthermore, there is considerable consensus, that such linkage effects tend to be rather weak (Bosson and Varon 1977; Emerson 1982; Gillis 1978). This follows from the "enclave" nature of mineral projects due to their often remote location, their capital intensity and technical complexity (Emerson, 1982, p. 563). Mineral projects are bound by the location of mineral deposits, often far away from established centers. Most less developed countries have little or nothing in the way of capital markets and cannot supply the capital necessary for most mineral projects. Similarly, since marketing opportunities are mostly in industrialized countries, and because the degree of tariff protection tends to increase with the degree of processing, there is little opportunity for forward linkages.

The second strategy for processing primary commodities in the country of origin was called "trade integration" by Johnson and Pintz (1985). It is based on the assumption that international mining companies are monopsonists (i.e. they act as one buyer), and that they tend to remove mineral rents from the mineral producing countries in order to avoid taxation.

Whilst this may be a valid strategy, its usefulness is qualified by the nature of the assumptions about the market for mineral concentrates and metals.

First, the market structures for primary and derived products may be oligopolistic, and may resist the entry of new suppliers. A new supplier on the market must, (i) be able to obtain sufficient investment funds in order to achieve the same scale economies as competitors; (ii) find and master the required technologies by purchasing the required equipment and employing technical manpower; (iii) find ways to market the product and find buyers (or tempt them away from the competing suppliers) if he is to survive (Roemer 1979).

Second, the market structure in ocean shipping means that monopolistic shipping conferences (cartels) may discriminate against exporters, either because their demand is relatively inelastic (i.e. they need the shipping if they are to sell their minerals or processed metal), or because shipping firms attempt to obtain a share of the savings associated with weight reduction and lower material loss in bulk shipping.

Third, processed goods may be subjected to increasing tariffs as the degree of processing increases. These qualifications of the applicability of the "trade integration" strategy are partly offset by the argument that forward integration into manufacturing can be a way to achieve more stable prices and sales volume (Smith and Wells 1975).

The fourth qualification to the trade integration motive for resource based industrialization concerns import substitution. Import substitution may be a way of avoiding the other problems noted above, and international resource firms may indeed be quite interested in producing behind high tariff walls. The problem is, however, that unless the domestic market is very large (or economic integration between nation takes place), such production will be inefficient and cause welfare losses (Roemer 1979).

That a country has a measure of comparative advantage as a result of weak or non-existent environmental regulation is advanced, by Johnson and Pintz (1985), as an argument for placing mineral industries, including processing facilities, in developing countries. Different

environmental standards may be the source of cost structure variations which give rise to comparative advantage (Nappi 1989). The corollary to this argument is that developing countries, being less heavily industrialized, posses a greater natural assimilative capacity (Johnson and Pintz 1985) and can therefore safely adopt less stringent environmental regulation. Whether governments in developing countries base policies on such an "advantage" is difficult to determine, but the emphasis industrialists in developed countries place on loss of competitiveness as a result of environmental regulation suggests that the issue is widely known.

Economic rent and mineral based development

The second major issue in minerals based development emphasizes the capture and use of mineral rents. In contrast to the previously outlined strategies, where the direct effects of the mineral industry were emphasized (i.e. mainly through employment of local factors of production and through linkages), the rent approach is based on analysis of four issues of economic policy, which, among others, determine whether countries have successfully achieved structural transformation (a significant decline in the primary sector share of employment, GDP and exports) or not (Lewis 1989).

The first issue is the question of how the host country can capture some of the economic rent from mineral production that would otherwise accrue to mining firms. Second is the question of how the rents, once they have been captured, are used, for investment or for consumption. Investment can be either in the same (primary) sector, in other sectors as part of a diversification policy, or in financial assets. Consumption, on the other hand, implies that the revenues from the rent capture effort are expended on current public or private consumption. The third issue concerns the linkages already mentioned above, but now in the sense of linkages resulting from the various possible uses of the rents. The fourth and final issue is that of stability. The size of revenues from rent capture will vary with the price of commodities,

and are thus likely to be very variable over time, creating a need for specific revenue management policies as well as for more general stabilization policy (Lewis 1989).

Before proceeding with an examination of these issues, it is instructive briefly to note the origins of mineral rents. This aspect will be discussed further in chapter 4, which deals with rent capture policies. Rents from minerals are commonly defined as the difference between gross sales revenue and total costs of production and marketing, including financial charges related to capital costs (i.e. including debt service and a "normal" return on equity). For a given mine the size of the mineral rents thus depends on the quality of the ore mined and on minimization of production costs. The flow of mineral rents, from the original source to the final consumption, is indicated in figure 3.1. The division used in the figure indicates that part of the economic rent is not captured by the host country government, but is retained by mining firms as a compensation for their willingness to carry risk. This share needs to be of a certain size, as it is that which drives investment in mineral exploration and extraction. For the purpose of the present discussion it is assumed that the host country is able to extract an optimal amount of rent. When considering revenues from taxation of mineral rents it must be kept in mind that the nature of mineral deposits means that the time profile of revenues is likely to consist of a period after production begins with no revenues (this is when capital investment is recovered), followed by a period with a relatively constant flow of revenues (depending on commodity prices and the structure of the tax regime). This lasts until the mine is exhausted, although sometimes it declines as lower grade ores are mined towards the end of the life of a mine.

The key questions in relation to development based on mineral rents are first the management of rents accruing to the host country and, second the linkages associated with the investment or consumption of the mineral rents (Lewis 1989).

The theoretical problem of choosing between asset acquisition and current consumption is one of comparing the net present value of future streams of income (if assets are acquired) to

current consumption. Spending will be allocated according to valuations of consumption today and consumption tomorrow, evaluated at the appropriate discount rate. In many developing countries the pressures on government to consume rather than invest are very strong and, combined with the apparent disregard for the economic return on projects, this indicates very high interest rates on the consumption side (people need a very large return before they invest), while they are very low on the investment side (Lewis 1989).

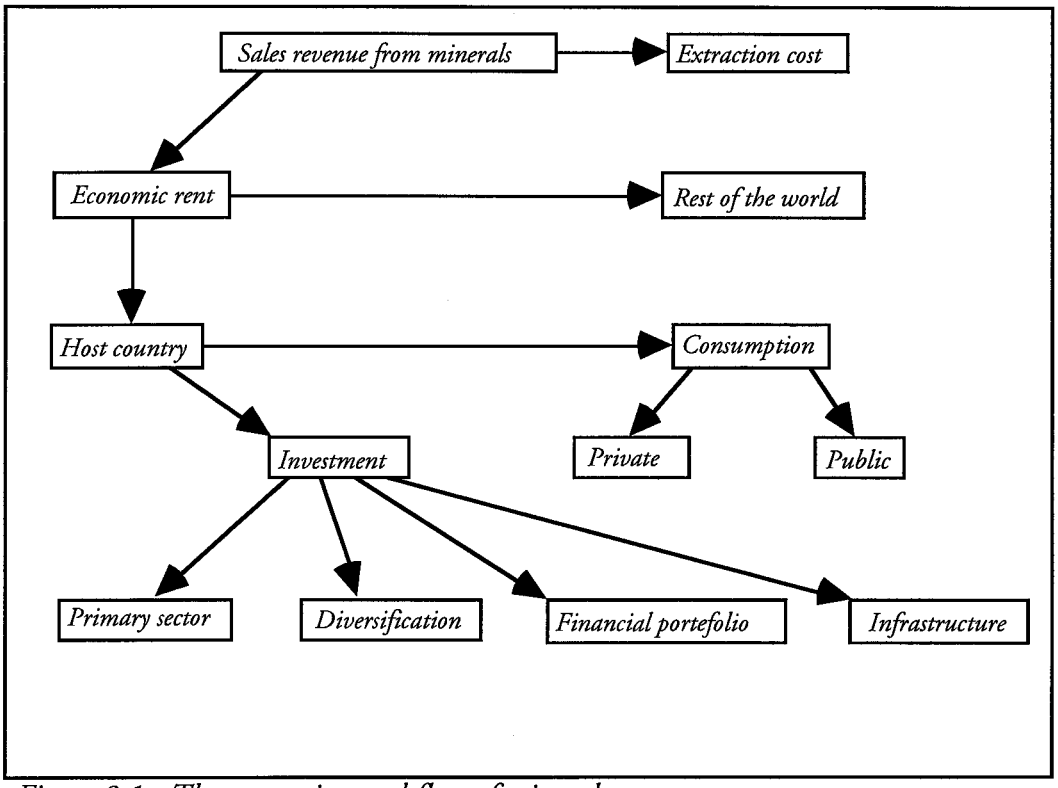

Figure 3.1. The generation and flow of mineral rent.

Most of the consumption possibilities noted in figure 3.1. have negative impacts on the mineral producing country and these will be discussed in the next section. On the investment side, however, the survey by Lewis (1989) indicates that the most important elements in successful development in mineral-exporting countries are investment in infrastructure, human capital and research. Investments which promote productivity growth and diversification seem particularly important, even if the latter process takes place in the primary sector. Furthermore, revenues used to mildly encourage and moderately protect

domestic production (especially if the protection does not emphasize quantitative import restrictions) is distinguished by Lewis as elements in successful development. The need for moderation in the protection provided (i.e. tariffs and/or subsidies to domestic production) follows from the requirement that the protected industry becomes competitive on its own. Too much assistance will not encourage efficient production.

The option to invest in financial assets, either at home or abroad is not often considered by governments. In some ways, however, it would not be inappropriate to place at least part of the revenues from non-renewable resource use in a diversified portfolio of low-risk financial assets. This could serve several purposes, the first to spread over time the introduction of rents into the economy, thus reducing the problems rapid consumption (or investment) of rents might have. Second, the income from a pool of financial assets may help secure future generations a share of the benefits of a natural resource endowment. Third, investment in assets may prevent individuals or groups from appropriating part of the rents for themselves through rent-seeking activities. Unfortunately, governments have only rarely been able to accumulate financial assets for later use. The few examples include Indonesia (Harberger 1984), the province of Alberta and the state of Alaska (Robinson and others 1989). This possibility is considered in chapter 9.

Mining sector impacts and the Dutch disease

When a mineral-rich country develops its mineral resources this will invariably have an impact on the economy of that country as a whole. Mineral production implies exports, an inflow of investments and an outflow of profits, new patterns of labour use and changes in wage and income structure as well as in government structure. All these changes mean that the economy has to adjust in a range of different ways. Lewis (1989) has distinguished seven key features that characterize these changes, shown in table 3.2.

TABLE 3.1. MINING SECTOR GROWTH IMPACTS

1. Higher GNP per capita
2. Higher share of government revenue in GDP
3. Higher wages in the modern sector compared to average GDP per capita
4. Reduced incentive to invest in non-mining activities
5. Foreign factors of production have a higher share of income relative to GDP
6. More unequal income distribution
7. More migration from rural to urban areas

Source: Lewis (1989)

The effects of economic booms have been the object of considerable interest in the past 20 years, beginning with the observations of "boom" characteristics in the Australian economy in the 1960's (Gregory 1976). Since then a range of models have appeared which examine various aspects of "booms", many of which are related to natural resource production (Corden 1984; Corden and Neary 1982; Snape 1977). These studies all deal with the impact of booms that are caused in one of the following ways (Corden 1984):

1. An improvement in the productive technology of the sector which only occurs once and is confined to the country in question. This results in a favourable shift in the production function.
2. A large discovery of new resources in the country.
3. An exogenous rise in the price of the export good produced by the "booming" sector, none of the goods being consumed within the country.

The boom in the mining or resource sector has several effects. The main group of these has been called "Dutch Disease" after an article in *The Economist* newspaper (November 26th, 1977) which described some of these effects as they occurred in the Netherlands. Additional effects are described by Lewis (1989), and many cases have been examined which demonstrate the occurrences of Dutch Disease in mining and other non-renewable resource contexts (Gelb and associates 1988; Neary and van Wijnbergen 1986; Norton 1988). The basic model of the impact of a booming sector described by Corden and Neary (1982) involves three sectors in the economy, the booming mineral exporting sector, a "lagging" manufacturing sector, which produces tradable goods, and a sector which produces goods

manufacturing sector, which produces tradable goods, and a sector which produces goods which are consumed domestically (i.e. non-tradable goods). Each sector uses two factors of production, one common to all of them (labour), and the other specific to each sector.

A boom in the mineral sector caused in one of the ways mentioned above will initially raise the factor incomes in this sector. This extra income can be spent thus giving rise to a *spending effect* of the boom. This effect works through higher demand for non-traded goods, and this in turn pushes up prices in the non-traded sector relative to the tradable goods sector (from p_0 to p_1 in figure 3.2.a). This means that resources will be drawn from the two exporting sectors into the non-traded sector.

At the same time the mineral sector boom means that there are gains to be made in this sector (i.e. due to the higher factor incomes relative to the other two sectors), which draws the mobile factor (labour) out of the manufacturing and non-traded sectors. This is the *resource movement* effect. With respect to the manufacturing sector this means that production declines, without the non-traded sector being involved, resulting in *direct de-industrialization.* Labour, however, is also drawn from the non-traded sector resulting in a lower production of non-traded goods, thus shifting the supply curve upwards (from S_0 to S_1 in figure 3.2.b), and resulting in a restriction of output (from q_3 to q_2 in figure 3.2.b). This effect is called indirect de-industrialization. These are the elements in the Dutch Disease model, but in this framework a range of other factors can be introduced as assumptions are relaxed. If capital is mobile between the manufacturing and non-traded sectors in addition to labour, then capital can move to the sector where it can earn the highest return.

In the model, the capital intensive sector may be manufacturing, and in response to the resource movement (of labour out of both manufacturing and non-tradables) capital will flow to the capital intensive sector, causing it to expand. However, the spending effect will, at the same time, cause both capital and labour to move to the non-traded sector (Corden and Neary 1982). Conversely, if capital is mobile internationally within each sector (but not

between sectors), capital will flow from manufacturing to mineral and non-traded sectors, resulting in greater de-industrialization, while at the same time returns to capital in manufac

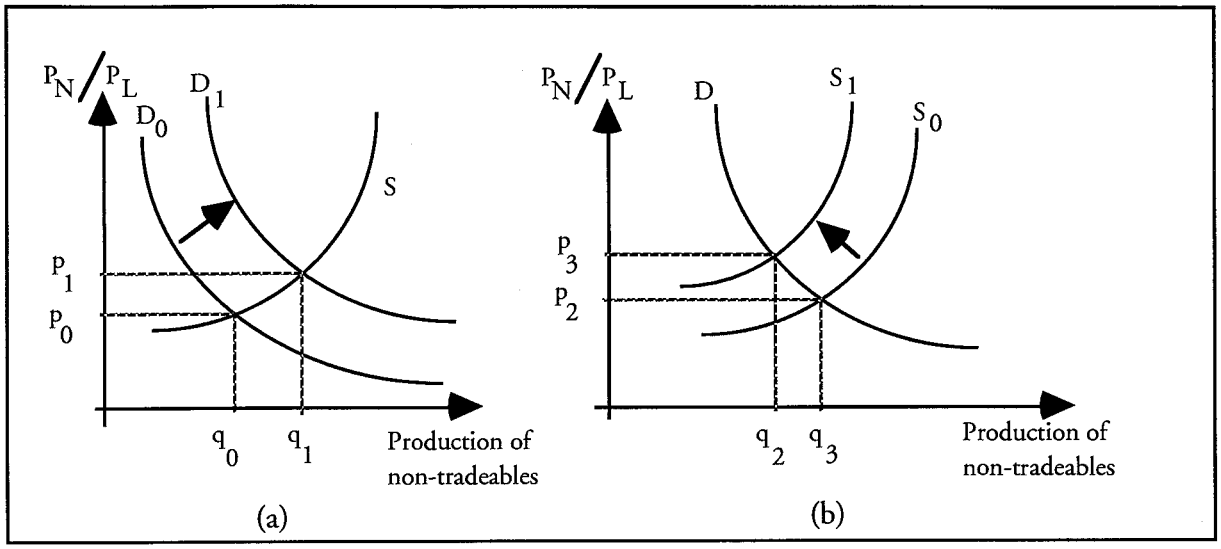

Figure 3.2. (a) The spending effect. P_N/P_L is the price of non-traded goods measured in terms of tradable goods. (b) The effect of resource movement on the output and prices of the non-tradable sector.

turing are maintained. Additional effects are related first to migration, which is induced by higher real wages in the booming sector, and which leads to at least a partial off-set of de-industrialization. Second, where the manufacturing sector produces both exports, and import-substitutes, there may be effects on world markets of mineral exports and at the same time de-industrialization as a result of resource movement effects (Corden 1984). Furthermore, if the economy is constrained by wage resistance a mineral boom may have employment effects. A rigid wage structure will cause employment to rise in the mineral sector as a result of a boom (instead of the real wage increasing) and, vice versa, in the case of a contracting sector wage rigidity would lead to unemployment. The extent of these effects depend on the nature of the workforce in individual sectors. A typical example of these effects would be resource movement away from a manufacturing sector combined with wage rigidity. The factor movement leads to unemployment in the sector, and this effect can be exacerbated if workers

in the manufacturing sector attempts to keep up with the wages in the booming sector (Nankani 1979). In the non-tradable sector on the other hand, wage resistance combined with initial unemployment will lead to increased employment as demand for non-tradable goods rises in response to a boom.

In the models described above, three elements noted by Lewis (1984, 1989) were not included. The first is related to the effect of excess liquidity in the economy, as a result of the mineral export generated balance of payment surplus. This excess liquidity will be even greater when the effects of fractional reserve banking on credit is also considered, so that the money and credit levels will increase more rapidly than GDP. Unless government and the central bank takes corrective action, inflation will be the result, as evidence from the Middle East petroleum exporters indicate (Morgan 1979).

Second, government revenues will increase, and with them government spending. This growth, however, is not accompanied by a corresponding increase in non-mineral revenues, and as mineral revenues level off and eventually disappear, government expenditures will have to be reduced (which is always a painful process). This growth in spending, with many new projects being undertaken, will also be likely to lead to carelessness in project appraisal, reduction of audit control, and a deterioration of management procedures, all factors contributing to wasteful spending.

Third, the expansion in spending on projects (mineral and others) causes the immigration and flows of international capital noted in the discussion of the Dutch Disease above. This has both economic and political implications. The immigration takes the form of import of services (and even more foreigners to monitor the first ones when the government can no longer do this job itself). Furthermore, the presence of foreigners in sufficient quantities can have de-stabilizing political effects. It is, however, in relation to the accounting of costs and benefits of a project, that these immigrants are most important economically. Whereas profits paid abroad are excluded from the calculation of project benefits, this is not

the case for wages, salaries and benefits paid to foreigners resident in the mineral producing country (Lewis 1989).

The existence of large mineral rents, and particularly if government succeeds in appropriating a large share of these, can create another range of problems. They can be described as "rent-seeking"[11], and may occur when large unappropriated rents, for example originating from mineral production, accrue to a government or state. Different groups will try to obtain a share in the rent by arguing that they have a special need for transfer payments. The State of Alaska is a good example of how rents are used in ways which indicate the influence of rent-seeking activities (Anders 1988). Despite the creation of the Alaska Permanent Fund (which is described in chapter 9), very large revenues from oil production have accrued to the State of Alaska since the early 1970's. Some of these have been expended on creating public goods in rural areas, and on creating artificial economies where entrepreneurship was insufficient. Considerable control over these efforts lies with the native corporations created as part of the Alaska Native Claims Settlement Act of 1971. However, these corporations have been unable to operate profitably, but have managed to appropriate significant funds for native oriented programs at the expense of coordination with state agencies.

Two additional long term effects should also be noted here. Initially, the consequences of a mineral boom on the manufacturing sector will be de-industrialization, which causes the sector to decline. In the process, however, accumulated human capital (i.e. learning by doing or know-how) can be lost, leading to long-term problems, when the boom ends or peters out (van Wijnbergen 1984).

11 Rent-seeking is defined as "any activity that attempts to improve a person or group's well-being by escaping the forces of competition in the marketplace" (Colander 1984). Rent-seekers, who invest resources in efforts to have transferred to them through political processes, cause an overall loss of welfare because the effort expended in obtaining a larger share in rents is not productive.

The second long-term problem of mineral booms is related to the effects of heavy external borrowing (Mansoorian 1991). This borrowing occurs in response to a mineral discovery, but when the time for repayment arrives it becomes necessary to introduce austerity measures. Thus, after a sharp increase in aggregate expenditure based on the expected gains from the resource discovery, there is a gradual return to a lower equilibrium level of expenditure. This lower level of aggregate expenditure also involves the non-traded sector, but the factors of production thus released can then flow into the manufacturing sector and promote industrialization in the long term (in contrast to the prediction of traditional Dutch Disease models).

Dependency on mineral exports

The concept that mineral producing developing countries are or become dependent on mineral exports to industrialized countries was at one time very popular. Roemer (1979) has surveyed the dependency arguments and distinguishes five aspects:

1. Trade dependence implies that industrial production and employment depends on export earnings which in turn finance imports of capital and intermediate goods.
2. Financial dependencies on foreign capital required to finance mineral exploitation.
3. Technological dependence is a question of access to technology controlled by international companies. It contributes to dualism, since the technology in the modern sector (as opposed to the primitive rural or agricultural sector) is not compatible with factor endowments of developing countries.
4. Managerial dependence refers first to the insufficient or absent training and education of the workforce in mineral producing countries and second to the discrepancy between training levels and the technology commonly employed in the mineral industry.
5. Market dependence is the result of the market power which integrated mineral producers posses (at least in some markets).

These types of dependence are additional to those associated with increased exposure to the fluctuations in world commodity prices, exchange rates and interest rates. Similarly, effects

associated with environmental externalities and with economic adjustments in mineral economies can also be framed in terms of dependence (Gillis 1978). Whilst some forms of dependence are quite important (financial, technological and managerial) in the short and medium term, it can be argued that many of the forms noted above are useful excuses for not being able or willing to undertake adequate management of mineral impacts.

MINERAL RESOURCES AND SUSTAINABLE DEVELOPMENT

The critical feature of mineral resources is their finite quantity - there are only those resources on earth with which it was originally endowed. Furthermore, the stock of mineral resources is unchanging: it does not grow like forests or fish stocks. It can even be argued that while the mass of mineral or non-renewable resources is constant, the law of entropy implies that mass will always tend to be dissipated and thus lost to economic use (Georgescu-Roegen 1973).

The possibility of a mineral resource being depleted also implies that the popular concept of sustainable development takes on a special meaning in relation to non-renewable resources. This is further complicated by the extent of environmental impact associated with the production of mineral commodities. This impact becomes increasingly important as resource production moves to deposits of progressively lower quality, where more material must be processed to obtain a unit of commodity. A further concern is the question of intergenerational equity in resource use and sharing of resource profits.

This section first examines the economic nature of non-renewable resources and discusses the implications for mineral depletion policies. Second, definitions of sustainable development are discussed (no clear definition of this term has been agreed upon), and the implications for the special case of non-renewable resources are reviewed. Finally, the result of the preceding two sections are integrated to provide the foundation for a mineral policy which is both fair and sustainable.

Non-renewable resources and optimal depletion

According to conventional economic theory, the nature of non-renewable resources dictates that they will be used in a well defined way, based on the conception of a mineral resource as a (sterile) capital asset. For the owner, the basic decision rule tells him to extract the mineral and invest the proceeds if the return from doing so exceeds the appreciation in the value of the mineral asset in the ground due to an increasing price. Conversely, if the return, measured as the relative price increase, from holding the mineral asset is greater than the return, measured as an interest rate, from investing the proceeds from mining, then the owner should keep the mineral in the ground. The result is a path for the resource price (net of all costs) rising at the rate of interest (see figure 3.3).

This is known as "Hotelling's rule"(Hotelling 1931), and is based on a number of restrictive assumptions[12]. Markets must be competitive, technology unchanging and all traders must be fully informed about present and future prices. Hotelling himself was concerned with the possible impact on the Pareto-optimal situation that exists when mining firms maximize present value. Wild "rushes" to acquire and exploit mineral land, unjustified windfalls to individuals with "free" access to exploration information, and the effect of high discount rates on the way firms choose to exploit resources may all contribute to disturb the equilibrium. Furthermore, since futures markets cannot provide information on future price, the risk of keeping an asset in the ground is higher, which may lead to more rapid depletion (Solow 1974b). Absence of future markets and contingent or commodity risk markets may, under certain price expectations, result in more rapid depletion (Heal 1975).

In practice, optimal depletion rates depend on a range of factors. The Hotelling model must be extended to include optimal savings rules and maximization of social utility. One model developed by Partha Dasgupta and Geoffrey Heal assumes production to depend on exploitation of an exhaustible resource, as well as on a reproducible capital stock

12 In algebraic form the Hotelling rule can be stated as $P(t)=P(0)e^{-rt}$, where P is the net price, t is the time from the beginning of the program and r is the interest rate.

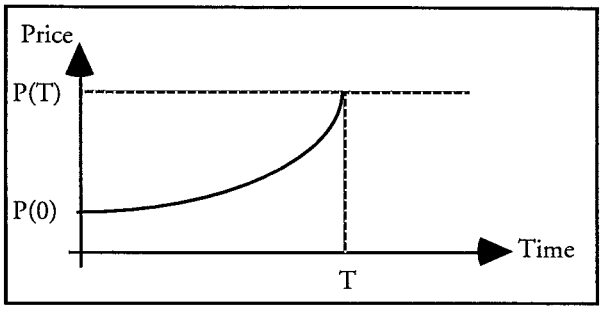

Figure 3.3. The path of net price over time according to the Hotelling rule

(Dasgupta and Heal 1974). Some of the production is not consumed but added to the capital stock. Consumption, however, benefits social utility, and the aim is to maximize this over time. In the model, the central problem is whether the resource is an essential input for producing the goods that are consumed. Further, optimal depletion depends on technological innovation which allows the development of substitutes to the non-renewable resource, and on the probability of discovering new resources. The extent to which capital can substitute for the non-renewable resource is similarly important. A positive rate of time preference and the fact that the model uses a utilitarian welfare function means that future generations lose out as consumption will decline to 0 (figure 3.4.).

Further extensions to this type of model indicate that constraints on consumption of the kind noted above can be avoided if endogenous technical change occurs. This, however, requires that some resources are diverted from consumption to technological research and development (Kamien and Schwartz 1978).

In all the models referred to above investment in reproducible capital plays a crucial role. The problem, however, is to make sure that "sufficient" investment occurs. Sufficient in this case means that there is enough investment to achieve technological advances which can offset the declining resource stock while a constant level of consumption is maintained over time. In other words, the essential question is whether the market will "save" enough. The answer is that it will, provided the social discount rate is 0 and no other distortions exist (Hartwick and Olewiler 1986). In cases where a positive discount rate applies, savings will

always be too low (Hartwick and Olewiler 1986, p. 165). The investment rule, known also as "Hartwick's rule", refers to investment of rents. These rents are the so-called "scarcity rents"

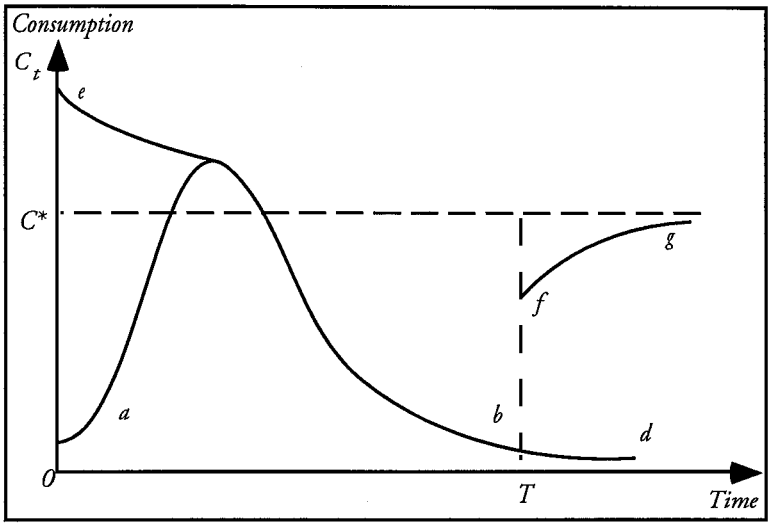

Figure 3.4. Consumption profile and optimal depletion of an exhaustible resource. The curve abd describes the case with a relatively low rate of time preference, whereas curve ebd describes the profile for a higher rate. If a technological breakthrough occurs at time T, the profile jumps to fg and settles at a fixed level of consumption C.*

(or Hotelling rents), which arise because the resource stock is constant. It is important to distinguish these rents from "differential rents", which are due to the variable nature of orebodies. A possible and practical approximation to this rule is taxing mineral rents and investing the revenue in capital projects (in a wide sense, ranging from physical capital stock such as infrastructure and production equipment, to human capital in the form of education, research and development), in special trust funds or through nationalization of the resource industry (see chapter 9 for an analysis of trust funds and the possibilities for using them in Greenland).

The implications of discounting derived above refer, however, to a closed economy (or to the global economy as a whole). When trade is introduced, matters are in some ways simplified since the rate of return is exogenously given. Optimal depletion is then given by

the rate of return on foreign assets. When uncertainty about future demand is introduced, it is the risk adjusted rate of return on resource assets which must be equated with the exogenously given rate of return (Dasgupta and others 1978).

For a developing country with substantial mineral resources the question of when to exploit becomes one of timing and discount rate. Despite the restrictive assumptions of the Hotelling rule, Lewis (1984) states that the general principle is sound, and that a country should deplete its resources and invest the rents (those accruing to the country), in such a way that the return on this new investment is driven down to equal that which is to be had by leaving the resource in the ground. If better returns are available on assets other than ore in the ground, the rule is clear: deplete as rapidly as possible. The corollary to this is that minerals should be kept in the ground when prices are rising at a rate higher than the discount rate.

The question of when to deplete is commonly raised in relation to the management of a developing nation's resources. As noted, following the Hotelling rule is one possibility, albeit fraught with uncertainties. This would in some cases imply a deferral of exploitation based on one or more of the following arguments, that over discounting favours present generations, that developing countries lack the managerial experience needed fully to reap the benefits from exploitation, that large projects may have a undesirable market impact, or that restriction of exploitation will allow producers to exercise market power (Radetzki 1992).

Adoption of too-high discounting rates is sometimes asserted to cause intergenerational inequity by depriving generations in the distant future of the resources they will need to maintain a reasonable standard of living (Meadows and others 1972). The high rate of depletion early in the period caused by high discount rates may also lead to conservation policies on a national level. The purpose here is to retain the resources for such a time when they can be used by a domestic industry rather than exporting them now. Typical examples of such policies are Canadian Uranium in the 1970's (Radetzki 1979), and iron ore in Venezuela in the 1980's (Radetzki 1985).

A higher discount rate will change the price path over time in the Hotelling model, and tilt the depletion profile towards the present. The question, however, is whether the model, on which this prediction is based, holds. With respect to timing of mineral depletion, the model has been used to argue that, since the present value of mineral depletion (i.e. net price) is independent of when extraction occurs, nothing will be lost by waiting (if this is required for other reasons). Marian Radetzki (1989) believes that the argument is false, and that the Hotelling rule breaks down when assumptions are relaxed.

The first problem of using the Hotelling rule to defer depletion is related to the co-existence of mines of variable quality (i.e. with different costs). The key issue is the different royalties such mines will earn. Radetzki (1989) envisages a sequential move to deposits of declining quality, and notes that although royalties are adjusted downwards they continue to increase at the rate of interest, thus maintaining the rationale for deferring depletion. The problem of different quality mines can also be seen as one of variable extraction cost for producing one unit of output. In a modified Hotelling model with constant extraction cost, however, mines of different quality will produce alongside each other as long as they earn a positive rent (Neher 1990).

The second argument questioning the usefulness of the Hotelling rule concerns the effect of unanticipated new resource discoveries. Radetzki (1989) argues that massive discoveries cause unit discovery cost to fall and, since discovery cost must equal royalty (rent) at the margin, leads to a lower royalty. Thus, the discovery necessitates a new price path, and makes the increase of the royalty associated with a particular deposit quality implied by the Hotelling rule impossible. This can, however, be queried by observing that any deposit may be relegated to a lower price path without changing the shape of the path.

Changing technology in exploration may also reduce unit discovery cost in contradiction to the Hotelling rule and advances in technology may make new classes of deposits far more viable than those previously exploited while at the same time making the "old" deposits uneconomic. As an example of the latter effect, Radetzki (1989) mentions the development

of bulk mining and processing methods for copper early in this century, which marginalized existing copper mines based on high grade veins.

The arguments, used to pronounce the Hotelling rule useless as an excuse for deferring mineral production, are backed by the observations of long term price behaviour of major metals which shows a decline (Barnett 1979; Barnett and Morse 1963). This approach, however, does not take into account the result of modifying the Hotelling rule to take technology into account. A model developed by Slade (1982), for example, examines commodity price trends and incorporates the effects of output level, grade and time (which is a measure of technological change in the industry). The model indicates that, first, price (P) equals marginal cost plus rent, and second, that the rate of change in price ($\dot{P}$) equals the rate of change in marginal cost due to technical change ($\dot{k}$) plus the rent multiplied by the discount rate (ρ):

$$P=C_Q+\hat{\lambda}$$

and

$$\dot{P}=\dot{k}+\rho\hat{\lambda}$$

where C_Q is marginal cost composed of an ore grade dependent element and a time dependent technology element, and λ is the rent. Since the rent is always positive, price will increase when there are no technical advances to lower marginal cost. Conversely, if technical change is rapid price may be kept down or fall for a time. The empirical data fits the model very well, indicating that prices for most minerals follow an U-shaped price path, and that the minimum point on this path has been passed for primary base metals and petroleum (Slade 1982).

Regardless of whether or not the Hotelling model provides a valid foundation for postponing mineral exploitation at a given site, it is instructive to review the situations where such a solution has been considered.

Resource conservation through deferral of exploitation is advocated for two reasons, as noted above. The pleas for conservation may, however, be based on two misconceptions (Radetzki 1992). The first is that the stock of resources is given and finite, and the second is that technical advances or discoveries can make known deposits irrelevant. The stock of resources is, of course, finite in a physical sense. It is more open to interpretation whether the stock is finite in an economic sense. The results of Slade (1982) shows a long-term price path which has begun rising, indicating that depletion outpaces technical advances. At the same time, however, it is worth noting that stocks measured in years of supply at the current annual rate of production have remained around 30 years for most of industrialized time (Radetzki 1992). With respect to the possibility of technical obsolescence, the case for deferral requires that a deposit, if temporarily made uneconomic by technical advances, should later achieve a net value (rent) which, discounted to the time when deferral took place, is at least comparable to the rent obtainable by immediate exploitation.

For developing countries deferral of mineral exploitation has been advocated on the grounds that neither an institutional framework nor the necessary human capital is available for these countries to capture the potential benefits of mineral development. The argument has some historical relevance, witness for example the dismal experience of Zambia since that country nationalized its copper industry (Auty 1991). There is, however, another side to the argument. The missed opportunities of countries like Zambia can be seen as necessary costs of "learning by doing". The case against deferral for reasons of inadequate institutional framework is further strengthened by considering knowledge or human capital as just another factor of production. It is always possible for a country to purchase (or receive free of charge from the United Nations or other agencies) the necessary help for management of a mineral industry and for training locals to do the job. The not inconsiderable success of Papua New Guinea in managing its mineral wealth using outside help provides an instructive example.

Occasionally, very large projects are candidates for deferral because they may, if put in production, depress world mineral prices. This, however, is a very short-run consideration

since very large projects are usually also low-cost producers. Thus, in the longer term, they will force high cost producers out of the market and reestablish a higher price.

The overall conclusion which emerges from the above discussion is that the pertinent course of action for countries with viable mineral deposits is to encourage their immediate exploitation. The possibility of following the Hotelling rule and deferring extraction cannot be wholly dismissed, but application of the rule requires substantial consideration of the risks of waiting. These risks arise mainly from the possibilities of technical change and general uncertainty about future discoveries.

If development is deferred it is likely to be for other reasons than discussed above. Environmental considerations of projects can, when strict cost-benefit analysis is involved, lead to environmental costs (including foregone preservation benefits) exceeding the benefits from a project. This brings us to the question of sustainable development, to be considered in the next section.

Sustainability and non-renewable resources

Casual observation of non-renewable resources would suggest that their exploitation is fundamentally different from, and in conflict with the concept of sustainable development. This is not, however a viable assumption on which to proceed and we need to examine more closely the meaning of sustainability and sustainable development.

The term sustainable development was defined by the World Commission on Environment and Development (1989 - also known as the Brundtland report) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). This definition, however laudable it is, gives little guidance on how to accomplish the goal of sustainable development. Pearce and co-authors (1990) have suggested that sustainable development is conceived as a vector of development which is non-decreasing over time. The elements which describe this vector and the time horizon over which the process runs is open to

argument, except for the requirement that intergenerational objectives must be satisfied. The elements of the vector could include:

Increases in real income per capita;
Improvements in health and nutritional status;
Educational achievement;
Access to resources;
A "fairer" income distribution;
Increases in basic freedoms;

The preceding discussion of optimal depletion and savings rules indicates that under some circumstances use of nonrenewable resources can be "sustainable" in the sense described above. However, the question of sustainability in a general macroeconomic sense may be separated into three distinct issues (at last).

The literature on depletion indicates that constant levels of consumption can be maintained if technological advance is sufficiently rapid. Thus, the first issue may be described as securing the optimal level of savings in a situation where the actual size of scarcity rents are unknown.

The second issue is related to the first, but may be described as a stock problem. This refers to the relative shares of natural and manmade capital in the total capital stock. There are two schools of thought in this area as described by Pearce and Turner (1990). The first is based on the idea that the standard of living can only be improved if the stock of natural capital is increased (i.e. the two are complements). When a certain standard of living has been reached it may be possible to increase it further without accumulating more natural capital. The second school of thought views standard of living and natural capital stock as substitutes, such that an improvement in living standard can only be accompanied by a reduction in the natural capital stock. Within these extremes variations are possible, for example moving along a path where standard of living and natural capital are complements

until we reach a point where further increases in standard of living will involve reductions in the natural capital stock.

The third issue to be noted here concerns distributional aspects of the composition of the total capital stock. People and countries may be at different stages in terms of standard of living, while at the same time their opportunities in the future may be constrained by the actions of other people or countries.

The major distinction made by Pearce and co-authors in relation to sustainable development is between the meaning of the term itself, which is self evident, and the conditions necessary for reaching the goal. The key condition is that natural capital stock should be held constant. Whether this leaves room for changes in the composition of the stock, from natural to man-made stock (and back) is unclear, as is the question of whether the two types of stock are complements or substitutes. The essential problem according to the authors is that such questions cannot be answered without a more clear-cut valuation of the economic services provided by the environment (Pearce and others 1990) and ways of comparing different costs and benefits. As these occur at different points in time it is common procedure to discount costs and benefits to some fixed point in time in order to reach a decision. Discounting, and especially the rate at which it occurs, however, is the source of much disagreement.

Initially it is instructive to note the effect of a change in discount rate in the management of non-renewable resources. The simple Hotelling rule, whereby the net price (sales price less extraction cost) increases from p(0) at the rate of interest, implies that a resource is exhausted when the price rises enough to choke off demand at time T (see figure 3.5). If, however, the interest rate rises, price will increase more rapidly, but from a lower initial price, P*(0) and the price path will be steeper, ending with economic exhaustion at time T* .

Thus, resource depletion is shifted towards the present[13]. This is the background for discussions of which discount rate to apply to the evaluation of projects. Many environmentalists argues that it is wrong to apply the market rate, and that the social discount rate should be adjusted downwards.

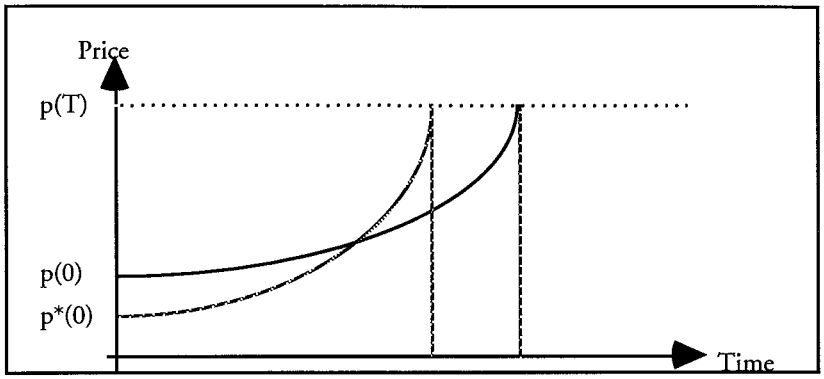

Figure 3.5. The effect of an increase in discount rate on the optimal price path

There are good reasons for applying a lower discount rate to evaluate environmental projects with long-term impacts. Private discount rates may differ from social rates in relation to future generations because the consumption of these future generations is considered a public good by present generations (Fisher 1981). Similarly, the discount rate applied by private individuals can include elements that have little to do with the concept of discount rate itself (i.e. time preference and marginal productivity of capital), but are used to adjust for perceptions of risk and uncertainty. Usually, adjustments to the discount rate are not, however reasonable the case for action, the best way of dealing with problems that are essentially unrelated with the discounting itself. Where discount rates are considered to be overly high, the problems are not solved by adjusting the discount rate used to evaluated projects but rather by seeking to lower interest rates in the economy as a whole (Fisher 1981; Pearce and others 1990; World Commission on Environment and Development 1987). The discount rate issue frequently arises when questions of environmental risk, irreversible damage

[13] The reason the price path begins at a lower P_0 is that the quantity of resource is unchanged (and foresight is still perfect) which means that only by starting at a lower price will the resource be used up (as it must be) when the choke price is reached.

and the interests of future generations are being discussed. In each case the implications of discounting and, in particular, of too heavy discounting, are unfavourable and controversial. Environmental risk exists but adjusting the discount rate by a fixed amount to reflect risk conditions does not adequately provide security against basic uncertainty about future events. A possible alternative is to try to adjust future income flows to reflect the certainty of their occurrence (Pearce and others 1990).

The possibility of irreversible damage to the environment can also be dealt with through other channels than the discount rate. This is done by including in the cost-benefit studies elements which take the benefits and costs of both a project and the status quo into account (Porter 1982). Thus, instead of the present value of a development being the discounted benefits less the initial cost, the calculation must take additional factors into account.

The first of these is the fact that development implies that alternative uses are lost. Secondly, the benefits B(D) and costs C(D) occurs in asymmetric streams. Technological advance and exhaustion will render the physical product which is the result of development less valuable over time. At the same time preservation of environmental amenities implies a growth in their value, since their supply is inelastic and demand growing (Porter 1982). These characteristics can be captured in the present value (PV) determination by first introducing an element to account for the foregone benefits of preservation B(P):

$$PV=B(D)-C(D)-B(P)$$

If cost of development is set at -1, q is the rate of decline in benefits from development, and z is the rate of increase for preservation benefits, the present value of development can be written as:

$$PV=-1+\int_0^\infty De^{-(r+q)t}dt - \int_0^\infty Pe^{-(r-z)t}dt$$

$$= -1 + \frac{D}{r+q} - \frac{P}{r-z}$$

The first of the two integrals here represent the present value of all development benefits discounted at the rate (r+q), where q represents the declining value of future development benefits. The second integral represents the future benefits of preservation which are discounted at a lower rate than r (r-z), as a result of the increasing value of preservation.

This implies that the discounted net benefits of development are positive only if the social discount rate falls within a certain range. If it is low, preservation benefits will dominate because these will accrue for a long time and will receive significant weight at low discount rates. On the other hand, if the discount rate is too high, preservation benefits receive little weight.

Despite problems in estimating preservation benefits, the approach outlined above can be used by first calculating the benefits of development, and then using this as a measure of what the preservation benefits would have to be in order to justify blocking development (Pearce and others 1990).

Finally, the question of how the interests of future generations are taken into account. The main problem is that costs and benefits which occur far into the future receive decreasing weight as the discount rate increases. Similarly, a high discount rate will discourage investment, reducing the capital stock available to pass on to future generations (Pearce and others 1990). While using the market discount rate as the social discount rate in relation to future generations may be a problem, the central question is whether it is reasonable to discount at all when the interests of future generations are considered. Instead, the interests of future generations should be taken care of in a different way, by first making an effort to measure environmental damage in monetary terms and then making a set of compensating investments which serve to maintain the services that flow from a stock of environmental capital (Pearce and others 1990).

The requirement for sustainability (that the discounted sum of environmental impacts should be 0 or less) is difficult to maintain for individual projects. With a program covering several projects, however, the constraint that the damage summed and discounted across the

program be equal to or less than 0 can be achieved. This is done by using "off-setting" projects that "improve" the environment to compensate for the damage done by the other projects in the program (Klaassen and Botterweg 1976).

The approach outlined above has considerable intuitive appeal. There is, however, one aspect missing: How is a program consisting of a number of environment depleting projects as well as "off-setting" projects to be implemented? While investors will be happy to invest in projects that deplete environmental resources, if it is profitable, it is more difficult to see the attractiveness of the off-setting projects. A second concern is that using such an approach, even where the off-setting projects are undertaken by government and financed from mineral revenues, is likely to be inefficient and may also result in distortions of incentives to minimize external effects of damaging activities.

Sustainable mineral policy

The mineral policy adopted by a country should, based on the issues raised above, be sustainable and intergenerationally equitable (albeit the former may be said to involve the latter). Sustainability involves both economic and environmental concerns, and the following rules summarize the basic elements in a sustainable policy:

1. Waste flows to the environment should not exceed the carrying capacity of the environment (Pearce and Turner 1990);
2. The reduction in the stock of non-renewable resources should be compensated by an increase in social capital corresponding to the value of aggregate rents from non-renewable resources (Hartwick 1977);
3. The efficiency of resource use is increasing with technological advance, leading to decreasing intensity of material consumption (Pearce and Turner 1990).

In practical terms, this indicates the importance of the task facing the resource manager. First he must determine what the carrying capacity of the environment is, taking into account both environmental impacts over which he has influence and those impacts he has no control over

(e.g. transborder or global pollution). The determination of the carrying capacity of an area or region or country involves both environmental capacity and the economic value of this capacity in alternative uses. Thus, economic valuation of environmental assets and services becomes an essential part of resource management.

Secondly the resource manager must make sure that an optimal amount of rents are saved in order to treat future generations fairly. The most interesting approach to this problem seems to be accumulation of [part of] the revenues appropriated by taxing resource rents in special trust funds. It must be noted, however, that in practice it will be very difficult to determine exactly what constitutes resource rent and then to save all of the rent for posterity. The practical experiences with trust funds will be taken up in chapter 9 with a detailed discussion based on the experiences with trust funds in Alaska and Alberta.

CONCLUDING REMARKS - MINERAL DEVELOPMENT AND SUSTAINABILITY

In the long run mineral based development and sustainable development are very closely related. The essential feature of sustainable development is that it takes the opportunities of future generations into account. In this chapter the concept of sustainability was viewed in terms of the total available stock of reproducible capital, capital being very broadly defined to include anything from resource stocks, over various production implements to financial resources.

Although this was not the initial focus of the chapter, the discussion of sustainability serves to put the various types of mineral based development into perspective. The distinction between development occurring as a direct result of mining on the one hand, and that part of development which is based on investment of mineral rents on the other hand, is important.

In many cases the expected development due to "linkage" effects of "economic spin-offs" have not materialized. At the same time the potential boom from inappropriate management of mineral rents is very great, as the frequent occurrence of "Dutch Disease" indicates.

There are two possible remedies. One is to set up a form of trust charged with collecting and managing the benefits from mineral resources in perpetuity. The real reason for advocating such an approach is mistrust in politicians and their possible inability to account for the interests of future generations. The second remedy is to trust the political system and allow it to determine the best use of rents. However, if rents are to be spent it had rather be on investment than in consumption, with investment meaning use of the mineral revenues for those opportunities which have the highest expected benefits.

4

ECONOMIC MANAGEMENT OF MINERAL PRODUCTION

Production of mineral commodities will take place from mines of variable quality. At the margin, the revenues from selling the mineral will just cover the total cost of mining, including a return on initial capital investment. The mine at the margin defines the lowest quality mine. At the same time, however, there will be many mines where the revenues will exceed the cost of mining, where costs include all payments to various factors of production, including the minimum returns necessary to attract the investment in the first place. The difference between the revenues and the costs is commonly referred to as the mineral rent.

Various parties may lay claim to this rent. In many countries, ownership of sub-surface resources is vested in the state, and national governments frequently claim the right to appropriate the rent. In other cases mineral rights are tied to the ownership of surface land, and the landowner then becomes a claimant. Usually, none of these have the knowledge or desire to find and exploit the minerals, but prefer to contract out the job to mining companies. These will also argue that they need to share in the mineral rent in order to compensate for the risks they take on (exploration, market and political risks), when they decide to invest.

Regardless of the way mineral ownership is structured the state will usually want to appropriate some of the mineral rent. The first part of this chapter analyze the different methods of rent capture and their implications for economic efficiency and optimal resource extraction.

While mineral rent is a central issue in mineral policy design, a number of other aspects of mineral resource policymaking have important economic dimensions. Regulation of exploration, production and mine closure all involve effects which directly or indirectly influence the size of mineral rents available for government appropriation. These additional aspects of mineral management are discussed in the latter part of the present chapter.

TAXATION AND CAPTURE OF MINERAL RENT

As developed by the classical economists, rent referred to the revenue a landowner could obtain simply by owning land, including mines (Ricardo 1911). With respect to mines, however, two different views existed. In the second chapter of "The Principles of Political Economy and Taxation", Ricardo takes the view that the income of a mine consists of two elements. The "royalty" element is the compensation to the owner for the decline in value of the mine as a result of depletion. The "rent" element is due to different costs of production, arising from variations in ore body quality or location. The second view of rent is expressed in the third chapter of the "Principles", which is devoted solely to "The Rent of Mines". According to this second view, the rent of mines is directly comparable to the rent from land.

To resolve this ambiguity, it is necessary to take into account the fact that a mine has a finite value (being exhaustible). All of the net surplus of the mine can be regarded as rent because it is part of the property value of the mine, and the total amount of rent depends on the difference between the production cost at the mine in question, relative to the highest cost mine expected to be in production at any time. In other words, the rent can be measured in

present value terms without having to distinguish between "royalty" and rent (Garnaut and Ross 1983).

In discussions of rent there are two other matters deserving attention, the distinction between windfall rent and transfer rent, and the existence of quasi-rents. Windfall profits are the result of unexpected price or cost changes, while transfer rents occur in the mineral industry when holders of mineral rights are able to exclude entrants (investors) from gaining a share of the expected rents. Had there been no barrier to entry, the investors would pursue the expected rents until the return was no different from other uses of (investment) resources. Transfer rents exist for the natural and efficient reason that investment in mineral exploration, which is inherently risky, requires that the initial investor has a secure title to any discovery he makes (Garnaut and Ross 1983). Without this barrier to entry, there would have been no rent to argue about.

The second type of rent is the so-called "quasi-rent" which can cause problems in taxation. Quasi-rent can be described as a payment providing an incentive for a particular allocation of resources which would not occur in the absence of the quasi-rent. This type of rent is more of a payment to a factor of production. As an example, Garnaut and Ross (1983) mention the case of mineral exploration. If there is no adequate return on the accumulated body of exploration knowledge and technology in a mining firm in the long run, then investment in this activity will cease. This can happen if rents are taxed without regard to the existence of quasi rent.

When these limitations have been taken into account, the remaining "pure rent" can be taxed almost with impunity, since it will be non-distortionary and efficient (assuming that all other sectors are competitive). However, if a government seeks to capture all of the rent from mines, it runs the danger of removing the mine owner's incentive to control costs. The higher the share of rent captured, the greater the risk of "gold plating" (Anderson 1991).

Before embarking on a more detailed examination of various rent capture schemes we will look at some of the results obtained in Leland's (1978) analysis of the mineral (specifically oil and gas on the US outer continental shelf) leasing. The important premise to keep in mind is that special circumstances (the presence of transaction costs, information asymmetries and bankruptcy costs) conspire to remove mineral leasing problems from the perfect market paradigm, where risks are shared through perfect and complete contingent claims markets (Leland 1978).

The model developed by Leland analyzes the types of payment schedule which are optimal from the government's point of view. What is actually optimal is a little bit ambiguous since it depends on the risk aversion characteristics of both parties (i.e. government and firm). As an example, Leland cites the likely case where Alaskan Native corporations[14], which control potential oil and gas bearing lands, will be relatively risk averse as a result of their comparatively limited asset positions. When tracts are leased under such conditions, leases should provide for lower royalty rates or lower profit-sharing rates and higher cash payments at the initial sale of the lease.

In its simplest form the model assumes that the actions of extracting firms are unrelated to the payment schedule used for leasing, and that information is symmetrically distributed between government and lessor. Under these circumstances the shape of the payment schedule relative to the value of a tract depends on the rate of increase in government's and firm's risk tolerance with increasing wealth. When the information symmetry assumption is relaxed, the payment schedule should become increasingly convex[15], with increasing asymmetry.

It is, however, the other assumption, that payment schedules do not influence the firm's decisions, which is the more important. This is also well supported by empirical

14 The cases of Alaska Native Corporations is mentioned briefly in chapter 3, while another aspect is noted in chapter 9.

15 A convex payment schedule refers to payments which increase when the value of the mine increases (i.e. when profits increase). Put differently, increasing mine profits will be taxed at progressively higher rates under a convex payment schedule. The opposite applies to a concave schedule.

observations (Leland 1978). Whether government can observe the actions of the firm is debatable and may not be necessary, depending on the payment schedule. If this does not affect the firm's choice of action at the margin it will be an optimal schedule (theorem V in Leland). This holds as long as the government has a way of monitoring the firm's actions. Given this condition for optimality, Leland shows that both royalty schedules and convex or concave schedules are not optimal, but that linear (of the form P=a+bV, where P is payment, V is value to the firm and a and b are constants) schedules are.

The following subsections extend the general principles noted above, and examines five categories of mineral taxation instruments. Each has different implications for the tax-base, and several are wasteful from a social point of view. Closely related to the matter of taxation is the allocation of property rights to minerals. The way these are allocated can have significant implications for the tax base. The first section also considers some of the implications of how property rights to mineral land are allocated. Some of the property rights issues raised here will be taken up in the second part of this chapter.

Competitive bidding for leases

The three main categories of mineral right allocation are cash bidding, work program bidding (WPB), and "first-come-first-served". The pure cash bid system awards the mineral right to the highest bidder, and the government receives the sum of the winning bid. Given the the government objective of maximizing community well-being and securing efficient extraction of resources, this requires that government captures the present value of the pure rent from its mineral resources. For this, the simplest and most efficient prescription is to sell a mineral right at an auction (Garnaut and Ross 1983). Some plots will sell below their true value and others above, and across the industry, government would receive an optimal amount of rent and there would be no "windfall profits" of the kind discussed below (Bergstrom 1984).

The central argument in favour of cash bidding is that rents, being difficult to determine *ex ante*, should be valued by the market. The only way to do this and appropriate rent is to sell the right at auction (Nellor 1984). The structure of the bidding process will naturally influence the outcome, but it can sometimes be arranged in such a way that collusion is very difficult (Mead 1974), and such that bids reflect the bidders true valuation of the tract.

The cash bidding approach has been applied in the United States to allocate leases on the outer continental shelf (Mead 1974), but these positive results have been put down to "exceptional circumstances" such as low political risk and extensive competition in the bidding process (Garnaut and Ross 1983). More recent research (Hendricks and Porter 1988; Mead and others 1984) indicates that the success may not be quite as distinct as initially believed, the evidence in some cases pointing to bid-rigging or, alternatively, to some bidders being better informed than others.

The arguments against a wider use of the cash bidding approach are several in addition to the need for competition. A cash bid transfers all the risk of a project to the private investor. When very little information about an area is available (as is commonly the case in metals mining) this can result in bids not reflecting the value of the area, and prevent the government from capturing an optimal amount of rent (Garnaut and Ross 1983). However, if cash bidding is combined with a tax conditional on a specified minimum rate of return on a project, an optimal amount of rent may still be appropriated (Emerson and Garnaut 1984).

It is sometimes argued that the risk averse nature of private investors imply a need for the government to share in the risk, mainly through a tax. Such an argument ignores the fact that risk sharing in the private sector is generally easy through the mechanism of portfolio diversification (Bergstrom 1984). There are some risks that cannot be eliminated in this way, but these also persist when government allocate some of the risk to taxpayers. In any event, the transfer of risk to the taxpayers would only be relevant in the unlikely event that these are

less risk averse than private investors - and the market would presumably be better able than government to allocate risk to those willing to take it[16] (Nellor 1984).

Another problem in the cash bid approach is the possibility of a "free-rider" problem (Gilbert 1981; Nellor 1984), where a bid for a new area from a bidder with exclusive information will attract other bidders, who take the first bid as an indication of the value of the area - without knowing the underlying information. The problem is not large since the initial bidder, who has the information, will bid only to his estimated market value of the area. An uninformed bidder topping such a bid will lose and will, if rational, realize this and refrain from bidding.

The assessment of competitive bidding is thus ambiguous. It seems unable to deal with unexpected changes in mineral price which generate additional rents. If the mineral right is not somehow restricted, this rent will be outside the government's reach, unless it decides to change "the rules of the game" *ex-post.* Adding a time limit to the mineral right will not be an option[17]. The net result of a time limit is premature exploration and development of resources (Fane and Smith 1986). Similarly, the empirical studies noted above indicate that full competition may not be present in some lease sales where cash bidding is used.

When we turn to the other main form of right allocation by auction, work program bidding or work commitment bidding, more serious problems appear. If we disregard taxation for the purpose of the present discussion, a work program bid will always be topped by a bid offering an even larger work program, as long as the profit from doing so exceeds the return on the best alternative investment. In other words, work program bids will become increasingly extensive until all rents have been bid away (Fane and Smith 1986). This problem is compoun-

16 It must be emphasized that the risk discussed here relate to individual projects and not the risk faced by government, of fluctuations in mineral tax revenues.

17 To see this, consider an area or block, and assume that it will be released for auction as soon as someone shows an interest. These will bid and win the area and will then have a limited time to explore it. At the end of the period, the right will revert to the government if no discovery has been made. In order to retain the right, investors will explore it, even if the time is not considered right by the investor.

ded by two others. First, in the course of a work program it may become clear that no more, or a different form of exploration is needed. If government insists on completion, the resulting pattern of exploration becomes inefficient (Nellor 1984). Second, the rents dissipated by the work program bidding accrue to those who provide exploration services, with unfortunate distributional consequences.

Despite the serious objections to work program bidding it remains widely used. Bergstrom (1984) suggests that claims to the effect that work requirements "will ensure vigorous exploration" and will prevent "speculation" in mineral land are misguided. It will indeed result in (too) much exploration, and there is nothing wrong in "speculating" in mineral land, if an investor believes that an area should be explored, he will explore it when he finds that the time is right and not before. Indeed, as pointed out by Smith and Ulph (1982), the common emphasis on "forced" investment in mineral exploration is closely related to a preoccupation with short-term effects on employment, level of [regional] economic activity and government revenues (Smith and Ulph 1982). Work program bidding is extensively used, for example in the North Sea, although cash bidding has had some success (Dam 1976).

In metallic minerals, property rights are usually allocated by open access claimstaking or through administrative discretion, combined with minimum work requirements. Bergstrom (1984) argues that under such a system, an area will either be explored too much or too little, but seldom optimally within the limited term of the mineral right. Too much refers to areas subject to rights, whereas too little refers to other areas which are starved of investment because the first areas have to be explored so much. This is because mineral areas may have cost structures or probabilities of discovery which indicate a different path of exploration investment which differs from requirements. Thus, the area will be awarded to the applicant who accepts these terms, giving the same effects as described above for work program bidding.

It can be argued that a cash bonus bid system is based too heavily on the assumption that firms are willing to take all the risk of the mineral exploration and production process. If firms are risk averse they will tend to explore less, exploit too rapidly and bid too little (Leland 1974). The implication is that a combination of a bonus bid and a conditional payment in the form of a profit share bid is preferable. The cash component is an essential ingredient since it will deter bidders from offering very high profit shares. The advantage of the profit sharing bid is that it will transfer some of the risk to the government, a feature of profit sharing which is discussed further below.

Royalties and production taxes

A royalty is a rent tax based on the amount or value of the minerals produced. Sometimes known as a severance tax (for the minerals "severed" from the mine), it is imposed on mineral output (ore mined or concentrate shipped), on price or on the gross value of production. Being most responsive to price changes, the latter is the most common. This type of *ad valorem* taxes have two major advantages from a government point of view: they are very easy to administer, and they result in government revenue as soon as production commences (Kumar 1991).

The problem with royalties is that they cause good (i.e. economically mineable) ore to be left in the ground. The royalty increases the unit cost of production, and in turn forces the miner to raise his cut-off grade in order to maintain profits (assuming that the mineral is sold in a competitive market). Alternatively, the mine-operator may postpone production (Neher 1990).

Despite the high-grading problem, the royalty instrument is very popular. Apart from the two major advantages noted above, there may be several other explanations. The first is that if the royalty is applied at a low rate (usually in conjunction with other taxes) it will have only limited impact on production decisions (Kumar 1991), a result partly supported by simulation studies (Bradley and others 1981; Walrond and Kumar 1986). An additional advantage of using a royalty in the case of oil is that a slower rate of extraction may increase to-

tal recovery by maintaining pressure in the reservoir for a longer time. Whether this is actually an advantage depends on the discount rate used by the investor (Garnaut and Ross 1983).

Corporate income taxes

Compared to both cash bidding and royalties, a corporate income tax is more complicated to administer, since it is based on income after deduction of production cost and other allowable costs. As such it does not distort profits because the mining firm will seek to maximize both pre-tax and after-tax profit (Neher 1990). Instead the treatment of costs causes problems. Common deductions in addition to operating costs and royalties are taxes paid to other jurisdictions and interest payments. More problematic is the treatment of depreciation, research, training and environmental expenses. Likewise, the ability to carry losses forward and the treatment of exploration cost is of great importance (Kumar 1991).

For a true profit based tax, the tax base would be current revenues less current costs, the latter including current consumption of capital items. If actual depreciation rules do not reflect the true cost of capital, serious distortions are introduced (Nellor 1984). This problem can be compounded if depreciation rules are modified frequently and by inflation.

Provisions allowing mining firms to carry losses forward depend on two things, the accumulation rate and the definition of the losses allowed as deductions. If all losses are allowed for the calculation of the tax base (i.e. including exploration costs), then they should be carried at the interest rate on government bonds (Fane and Smith 1986). More frequently losses are carried forward without an interest rate adjustment. The allowed losses, and the rate they can be carried forward at, determine whether the tax is an income tax or what is known as a "Resource Rent Tax" (RRT), as considered in the next subsection.

Resource rent tax

The concept of a tax designed to capture the pure economic rent of mineral resources without distorting investment and operating decisions was first advanced in 1975 in response to a

growing need for developing countries to obtain more of the benefits associated with exploitation of their mineral resources (Garnaut and Ross 1975). This concept became known as a "Resource Rent Tax" (RRT) and was a modification of a simpler concept, the "Pure Rent Tax" (PRT).

A Pure Rent Tax involves a constant proportional tax on all net cash flows of a project. When net cash flow is positive, the government receives revenue, and when cash flow is negative, the government pays a subsidy corresponding to the tax proportion of the negative cash flow (Garnaut and Ross 1979). This type of tax, a modification of the so-called "Brown tax" (Brown 1948), in effect makes the government a partner in the project, with a share corresponding to the tax rate (Fane and Smith 1986). The advantage of a PRT is that it is fully neutral, it taxes economic rent only, and it is easy to administer. On the other hand, if it is applied at too high a rate it will remove the incentive for efficient operation.

The greatest problem of a PRT, however, is that along with the *de facto* share in the project comes risk to the government, in form of possible financial loss. Government may expose itself to the risk of substantial losses on projects which never result in production and may be unable to recover these from successful projects. Given the political problems associated with such a scheme, it might be just as well for the government to take an equity share in projects. These problems may also tend to make such a tax less than credible (Garnaut and Ross 1983).

The variety of rent tax which comes closest to the PRT, without involving the government directly, is the Resource Rent Tax. The RRT can briefly be described as a profit tax collected when a threshold internal rate of return on total cash flow has been realized. The main principle of the RRT[18] is that a range of receipts and payments are defined as allowable for calculation of the RRT. These are termed "net assessable receipts" and corresponds to the tax base. If, in the first year of a project, a net deficit occurs, this is carried for-

[18]The following description is based on Garnaut and Ross (1975).

ward at a predetermined rate of interest (the threshold rate). In the second year, the net result (deficit) is added to the amount carried forward from the previous year, and the total is then carried forward to the third year. When net results are positive they are deducted from the net assessable receipts account, and the remainder is carried forward at the threshold rate of interest. This process continues until the account becomes positive. At that point the RRT-tax rate is paid on the positive amount in the account. In subsequent periods, as long as net results are positive, the account is set equal to 0 and RRT is paid on the net result. If there is a negative result, the procedure for carrying forward is activated until the account is again positive.

In calculating net assessable receipts all operational payments to and from the project are allowed, as are other taxes and income from sale of equipment. On the other hand, financial payments such as revenues from loans and equity offerings, interest payments, dividends and loan repayments are not allowed for net assessable receipts. In its simplest form, the RRT with one threshold rate and one tax rate, is similar to a corporate income tax with the following special features:

1. No deduction for interest payments;
2. Immediate 100 % depreciation of all investment expenditures;
3. Unlimited carry-forward of losses at a specified interest rate.

Several tax rates and corresponding accumulation rates can be specified as a means of capturing extreme windfall profits at a very high marginal tax rate. The RRT scheme would require additional regulation to prevent investment in companies not subject to the tax, in order to prevent avoidance. Similarly, prices paid to the project would have to be monitored to prevent tax avoidance through transfer pricing. Finally, clear definition of where the resource extraction process ends and manufacturing begins is necessary, as is a requirement that the definition must exclude non-mining activities in order to prevent economic distortions (Garnaut and Ross 1983).

The treatment of exploration in the original RRT concept implies that all expenses in a country, by a given company, prior to the discovery of a profitable mine should be allowable expenditures when the tax is calculated for that mine. For subsequent exploration expenses[19], however, a new mine would be required before they could be used as deductions (Garnaut and Ross 1975).

There are a few apparent problems associated with this type of taxation, but most (such as administration, accounting etc.) are possible to overcome. The most important problem, especially when a country has few mines, is the long period before any revenue accrues to government. When many mines are in operation, revenues should be relatively stable. Inflation, exchange rate variations and measures to prevent double taxation are all problems which can be solved without unduly affecting the neutrality of the RRT approach (Garnaut and Ross 1983).

The preceding description of the RRT approach to capturing mineral rent is not, however, complete without a discussion of two inherent problems in the RRT, related to the threshold rate(s) and the distortionary effect some versions of the RRT may have on exploration investment.

The problems are basically related to the amount of risk involved in a project. Projects involving high risk (i.e. grass-roots exploration) will have a higher supply price of investment than will the development of low-risk projects (e.g. oil wells in a known oil-field). The question is, should these different projects be taxed under a RRT scheme using the same threshold rare of return ? This problem can be seen as one of defining what exploration expenditures are allowable for a given project (Bradley and Watkins 1987), otherwise a fixed accumulation rate will introduce bias against riskier projects. According to Bradley and Watkins, there is no way exploration expenditures can be attributed to particular reservoirs, and therefore exploration-intensive projects need to be awarded a higher accumulation rate.

19 This must refer to exploration outside the area of the first mine.

The type of problems described here can be illustrated by looking at a simple model of revenue collection based on the work of Bradley and Watkins (1987) and Fane (1986).

The model involves a two-stage investment process with exploration expenditure *E,* and development expenditure *D*. There is no delay between the occurrence of the two. The probability of discovery is *p,* and the probability of a successful development is *w* (this depends on market factors such as commodity price and costs). Here we disregard *w* since it is considered to be of far less importance than *p*. If development occurs, a net ongoing income, *S,* accrues at time T after development (revenue net of operating cost). When there is no tax, the net expected value of the project is:

$$V=-(E-pD)+pSe^{-rT} \tag{1}$$

where *r* is the opportunity cost of capital with no risk adjustment. The first term on the right hand side is total discovery and development cost, and the second term is the discounted value of income at time T. If a PRT was levied at a rate *s,* the expected value of the project would be:

$$V^{PRT} = -(1-s)(E+pD)+(1-s)pSe^{-rT} \tag{2}$$

However, if the tax were instead based on the RRT approach, using an accumulation rate of r^* (above *r*), the expected value would be:

$$V^{RRT}= -(E+pD)+pSe^{-rT}-sp[S-(E+D)e^{r^*T}]e^{-rT} \tag{3}$$

The difference between the PRT and the RRT is that the latter involves an additional tax on exploration as well as a subsidy on investment when the accumulation rate r^* is overly generous. To see this, observe the difference between V^{PRT} and V^{RRT}:

$$V^{RRT}=V^{PRT}-s(E+pD)+sp(E+D)e^{(r^*-r)T} \tag{4}$$

In this equation, the second term on the right-hand side is a tax on investment which occurs because the RRT, as formulated here (eq. 3), only allows exploration cost as a deduction when there is a successful discovery (i.e., in the third term in eq. 3, only the expected value of exploration and development, $p(E+D)$, is deductible). At the same time, the final term on the right hand side of equation 4 means that projects with low risk are favoured, whereas there is a bias against risky projects.

The implication of the tax on exploration which follows from the denial of full loss offsets is important (Fane and Smith 1986). It will tend to produce inefficiently low investment in exploration generally, and will discourage marginal projects altogether. Furthermore, the bias against risky projects implied by the third term on the right of eq. 4 is compounded when a generous accumulation rate is allowed, due to the incentive for mine owners to delay production in order to get maximum credit for accumulating losses. The general effect of denying full loss offset and using an accumulation rate above the base rate unadjusted for risk is under-investment in exploration and over-investment in development.

To get around the problem of full-loss offset, Fane and Smith suggest that unused exploration credits from unsuccessful projects should be tradable if they cannot be used by the companies themselves. A model along these lines was under consideration in the mid-1980s, when Australia introduced a RRT type tax on-off shore oil production.

Provided a number of conditions apply, trading of unused exploration credits would remove the distortionary effect of a rent tax on high-risk exploration investment. The conditions are that the market for the credits must be competitive, that total profits subject to the RRT must exceed total losses in the market, and that exploration credits cannot be deducted elsewhere for calculation of the rent tax (Garnaut and Ross 1983).

The threshold rate at which accumulated losses are carried forward can either be set individually for projects (along with the tax rate), or be the same for all projects (and then possibly differentiated according to the riskiness of the type of expenditure). However, since govern-

ments will be unable to obtain the information needed to set individual threshold rates, and because tax conditions fixed in advance will, *ceteris paribus,* tend to lower the discount rate applied by investors, Garnaut and Ross (1983) believe that both the threshold rate and the tax rate should be set in advance. Then, to avoid the dangers of having set these rates too low, there should be several thresholds with corresponding higher tax rates (e.g. first threshold 15% with a tax rate of 50%, the second at 20% and 60% tax e.t.c.).

In contrast, Fane and Smith (1986) show that, provided full loss offset is possible (i.e. all exploration expenditures are allowed as deductions), the threshold rate should be equal to the interest rate on government bonds. The argument is that if the company is certain that it will be allowed to use the RRT exploration credit, the risk of the project as a whole is not affected because there is no risk involved in the valuation of the exploration credits.

Risk and the choice of rent tax instruments

The risk faced by an investor in mineral exploration and subsequent exploitation comes from both technical and institutional sources. Technical risks include existence of deposits, possibility of extracting them, and market conditions. Institutional risks refer to the environment where discovery and extraction of minerals takes place. This type of risks, sometimes called "sovereign" because they are related to the actions of governments, have a considerable impact on investor behaviour - and thus on the size of mineral rent available for taxation.

It can be argued that a RRT combined with an element of cash bidding is the best way of responding to investors and governments various responses to risk (Emerson and Garnaut 1984), with emphasis on conditional payments when the government is less averse to risk than the investor. Heavy reliance on conditional payments is also necessary when a large element of sovereign risk is present. This risk basically arises when there is an expectation that the tax system will be modified, usually as a response to windfall profits accruing to investors. The problem of sovereign risk, however, is that if a tax system appears "over generous", the investor will expect it to change in a way unfavourable to him and will increase his mini-

mum acceptable rate of return accordingly. Then, if the tax system is not modified, investors will obtain an unexpected profit because he preferred to "fear the worst". This type of problem can give rise to an unfortunate series of conflicts between investors and government (Faber and Brown 1980).

That design of rent capture systems is more complicated than the simple discussion above may suggest is emphasized by both Kumar (1991), and Bradley and Watkins (1987). The problems are two-fold, the first is to devise rules able to cope with the problems set out above, mainly in relation to risk and the treatment of exploration cost. Second is the need to integrate what is theoretically attractive with the needs and desires of the government. The latter problem will often turn on the timing of resource revenues, and the practical solution might easily involve a combination of a small production tax and a RRT framework (Kumar 1991).

When a mineral rent tax is considered alone, the two better approaches which appear from the above discussion are cash bidding and a RRT with extensive loss offset, or possibly a combination of the two. The choice of instrument, however, cannot be made without reference to the tax system of which it will be part and the nature of the mineral resource in question. Similarly, there can be a range of other issues that dictate the choice of rent tax instrument. Some of these are considered below.

An application of the Resource Rent Tax

Mineral taxes similar to the types described above have been reported from a number of countries (Kumar 1991), where they are frequently combined with other forms of taxation, primarily standard corporate taxes. Here we will examine the system used in Papua New Guinea (PNG), the country which pioneered the RRT approach[20]. The description is based on the 1990 form of the system reported by Kumar (1991).

[20] The government of PNG does not rely solely on taxation to obtain mineral rent. In a number of major developments the government has taken a minority share in the operating company (Pintz 1984; Wilson 1984)

The PNG mining tax system consists of a standard corporate tax, currently at 35% of taxable income. This income is calculated in the ordinary way, with depreciation calculated in a rather complicated way. In addition to this, an additional profits tax is applied according to the following general formula:

$$APT = NCR(70-n),$$

where NCR is net cash receipts and n is the corporate tax rate. The NCR is defined as:

$$NCR = Y-D-C-Ex-P-T-I,$$

where
Y = Income in the current year from sales, stock reductions and asset sales;
D = Allowable deductions, not depreciation and interest payments;
C = Capital expenditures in the current year;
Ex= Exploration in the current year;
P = Equipment bought in the current year;
T = Corporate taxes paid in the current year;
I = Increases in inventory of input materials.

The expenditures at the beginning of the project are carried forward at the interest rate r*, until they have been offset by income. The NCR is also calculated for years with no income. Under the rules, r* can be either 20% or the average US prime interest rate plus 12%. When the accumulated losses have been offset against income, the NCR is calculated as shown. When the carry-forward rule is included the APT for year t can be stated as follows:

$$APT_t = NCR_t\ (70-n) = [NCR_{t-1}(1+r^*)+Y-D-C-Ex_t-P-T-I]\ (70-N),$$

where NCR_{t-1} is carried forward at r* as long as it is negative. With respect to exploration, expenditures older than 11 years are not allowable.

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and lately has forced Placer Dome Mining Inc., a Canadian mining firm, to part with an additional share of the Porgera gold mine (Mining Journal Newspaper, March 19th, 1993, p.201).

In relation to the discussion above, the PNG tax system for mines departs from the simple models in a number of ways. The most important is that it combines normal corporate taxation with a variant of the RRT. This approach may be preferable in relation to certain international standards and tax treaties. It is possible, however, that in some cases mineral investment is derived exclusively from overseas sources. If that is the case there is no need to place mining and other domestic industries under the same conditions to avoid distortions, and a RRT can, in principle, be used alone (Garnaut and Ross 1983).

State mineral enterprises

State mineral firms are a special approach to capturing mineral rents. In view of the later discussion of state companies in Greenlandic setting a brief discussion of the topic is given here. The classical account of state mineral enterprises is Marian Radetzki (Radetzki 1985), and the following is primarily based on his work.

Three characteristic features distinguish a state [mineral] enterprise from private firms. These are state ownership or control over the enterprise, the private goods nature of the firm's output, and the general business orientation of the enterprise. The reasons for establishing a state enterprise may be both economic and political. The first economic reason involves lack of competition on two levels: When the mining firm has market power in domestic markets (i.e. for local supplies and local skilled labour), and when the mining firm has market power in mineral markets, which may be detrimental to the developing country hosting the mine. The second economic reason is that a state mineral enterprise can be used for rent capture when the general fiscal system is unsuited for this purpose.

The political reasons range from the purely ideological concept that state ownership is always the best solution to more pragmatic reasons related to regional development and national security. In relation to developing countries, the end of colonialism and the need to break away from colonial emancipation has constituted a reason in itself.

The curious conclusion of Radetzki's investigation is that it is not cleat that state mineral enterprises have performed significantly worse [or better] than private companies, nor do they seem to have had significant impact on mineral markets. The most clear conclusion of the study is that by 1983-84 the growth of state mineral firms has slowed almost to insignificance, and that the confrontation between multinational mining firms and developing country governments has been much reduced.

ECONOMIC MANAGEMENT PROBLEMS

Apart from the central issue of mineral rents, two other areas where economic considerations are important for management decisions must be analyzed. These are mineral exploration investment (which is a prerequisite for any later revenues), and environmental regulation, including the commonly used (but difficult to define) concept of "sustainable development".

Mineral exploration investment occurs in lands where investors believe a high probability of discovery exists and where other risks (of failure) are low. However, as was the case in the above discussion of cash bidding for leases, ideal conditions may not prevail. The first section below will attempt to clarify the problem and the possible implications for mineral land management.

Environmental management in the mineral industries has traditionally relied on command and control styles of regulation. Only in recent years has the industry seen the use of market oriented regulation. The primary tool has been "reclamation bonds" which are used to ensure that sites are returned to an acceptable standard at the end of mining. The second section below takes a closer look at this practice, its impact, and on other possibilities of market oriented instruments.

Mineral exploration

Exploration investment by mining firms is motivated by two considerations. One is a desire to replace reserves as mining depletes previously discovered orebodies in order for the company to remain in mining (such that replacements are as good or better than before). The other is a search for deposits which cost less to extract (and earn higher mineral rents). In some cases information on the total stock of a resource may also have value to a firm, provided the information allows the firm to speculate in the resource price (Dasgupta and Heal 1979; Gilbert 1979).

Investment in exploration is also important to any given jurisdiction since it increases the probability of discovery, within the jurisdiction, of orebodies which may eventually generate some of the benefits discussed in the previous chapter. The occurrence of exploration investment and the way it is made depends partly on how the process is regulated.

We must begin with a look at how markets influence exploration investment - and how they can fail in ensuring optimal allocation of such investment. First we must note that the information produced through exploration can have both public-goods and speculative value (Gilbert 1981). The public good value can be separated into "local" information externalities, and those which are related to the size of total stock of a resource. Here we will concentrate on the former, and on the speculative value of exploration information, since these have clear implications for the way mineral exploration is regulated.

The term "local" refers to situations where the returns from exploration by one firm confers external benefits on other firms. Thus "local" is used in a non-spatial sense to cover a wide variety of situations. For example, the discovery that certain varieties of garnet minerals (pyrope) in kimberlite rocks indicates the presence of diamond-bearing kimberlite rocks may be made by one firm in South Africa, but may have extensive external effects in the Northwest Territories of Canada.

The consequences of the externality depends on the degree of public availability of the information. If the public (other firms) have no access to the information, firms will explore separately on land where only one firm had needed to explore, if the information was public (i.e. discovery on one tract implies discovery on neighbouring tracts). In the case of the pyrope garnet indicator, mineral firms would undertake research separately to develop the knowledge. The result is a problem closely analogous to those observed in R & D generally, redundant investment. In the case of exploration, over-exploration (Gilbert 1981).

When information is fully public, both timing and the pattern of exploration may be distorted. Exploration may be delayed as firms wait for useful and free information to become available. At the same time the public availability of information may lead firms to explore in more remote areas, where information can better be kept private (Gilbert 1981). This also means that lands where exclusion is possible for some reason (remoteness or as a result of regulation) may be explored too early and too intensively.

The other cause of market failure in exploration comes from the speculative value of information. This problem has been examined primarily in relation to competitive bidding for leases (Gaskins and Teisberg 1976; Gilbert 1981), and has stimulated much research on auctions and their design (Hendricks and Porter 1988; McAfee and McMillan 1987). In relation to lease sales by auction, Gilbert (1981) notes two possible effects. The first concerns location (in a spatial sense now), and the second concerns timing.

By examining the value of being informed in advance of an auction and having it take place as early as possible, Gilbert finds that the possibility of obtaining monopoly rents leads to more information in relatively unexplored areas (i.e. having the auction early, other firms are less able to value the land and put in a winning bid). Similarly, Gilbert finds that a competitive bidding market may provide incentives for too early exploration.

In mining land disposition, as opposed to oil and gas leasing, a "first come - first served" rule most commonly applies. In relation to mining, the distortions related to lease sales at auction are probably not important, whereas the distortions related to information externalities remain unchanged. In fact, their presence seems clearly indicated by the regular occurrence of "staking rushes" in the vicinity of new discoveries.

The distortions resulting from the public-goods and speculative nature of exploration information has a number of implications for mineral leasing and title disposition. The research on auctions mentioned above has led to the design of auctions which to some extent can discourage investment in exploration for speculative purposes (McAfee and McMillan 1987). Some of the distortions apply specifically to auctions or to claim-staking, while others apply to both.

First is the diligence requirements occurring in both forms of disposition. These specify that the holder must undertake production or exploration within a specified time after the lease was issued or the claim recorded. However, in cases where the lease or mineral right was issued prior to the time when the firm holding it considered exploration or production optimal, such requirements leads to a combination of over- or under investment in the sense that areas subject to leases or rights are explored too much, whereas other areas are starved of investment (Bergstrom 1984; Gilbert 1981).

The incentive to wait until a discovery is made and then rush in has been observed in relation to oil reservoirs, where, after the initial discovery, firms rush in and try to pump as much as possible from a reservoir which is really common to many firms. The result is a situation where even very large common-pool losses were an insufficient incentive for the firms to reach a unitization agreement (Wiggins and Liebcap 1985). The problem can be addressed by compulsory unitization, although implementation of such policies can involve a long fight (Libecap 1989), if the issue has not been addressed comprehensively in advance of leasing.

Disclosure of exploration information is thought to increase the share of the lease value captured by the seller, and to reduce the incentives for private accumulation of information

for speculative purposes. Whether this is a useful approach depends on firms ability to circumvent disclosure (e.g. by randomizing the data), and on the lower value of bids resulting from less exploration for speculative purposes (Gilbert 1981).

The final implication concerns the role of government exploration prior to leasing. This can be a way to reduce excessive pre-sale exploration. However, the exploration decisions made by a government-run structure are not necessarily more optimal than those made by and in-optimal market process. Furthermore, exploration by government may not pursue as widely different exploration strategies as would firms in a competitive environment (Gilbert 1981).

The previous paragraph indicated that government run exploration may not be an alternative. However, governments in all countries engage in research which is closely related to mineral exploration. There is little information available on why governments find the maintenance of extensive geological surveys necessary, but we can speculate that markets are unable to allocate investment to the kind of basic research carried out by the surveys. One possible explanation may be that investment in the early phases of exploration is provided by private investors, because the information, and the acquisition of title to the tract being explored, represents prohibitively large sunk cost. It is important to keep in mind, though, that support for such purposes can expand into activities that are clearly subsidization.

In the short run, exploration promotion policies may result in new discoveries but the main problem of such schemes is that they become unstable in the event of major discoveries. When such discoveries are made, there will invariably be intense pressures to recover the subsidies of the past, and the resulting tax-increases can be distortionary and can so undermine investor confidence that investment in exploration and development is reduced sharply.

For the regulating government the problems associated with diligence requirements poses the question, what are the alternatives ? From the discussion in the previous sections it is clear that cash auctions are a strong possibility. However, while this solution is frequently

used in the petroleum industry, it is very rare in mining[21]. Therefore it is also unfamiliar to most mining firms.

An alternative solution would be to lease tracts to mining exploration firms from the earliest stages of exploration. The positive cost of holding the tract would then be an incentive for the firm to hand back areas not deemed interesting to the firm. However, this leaves unresolved the problem of determining the price of the lease.

Finally, the most sensible solution appears to involve the old-fashioned system with diligence requirements, but in such a way that distortions are minimized. This may be possible by keeping the amount of required work low, by allowing concentration ("grouping") of work carried out in a large permit area on smaller areas as uninteresting areas are handed back, and by allowing and facilitating trade in, and transfer of mineral titles. A further aid in reducing distortions could be the use of tradable exploration credits.

Environmental management

The economic management of mineral production can, at least conceptually, be said to include that part of environmental management which has economic implications for the mining enterprise. Several issues are considered here. First is the indirect effects of environmental regulations as a whole on investment decisions. Second is the question of how actual environmental regulations are structured (i.e. whether they use direct regulation or economic incentives). Third are the possibilities of using market based incentives to achieve more efficient environmental protection in the mining industry.

Strict environmental policies will generally increase operating cost at a mine. How mining companies deal with such rising costs is not well known, but there are three possible paths they

[21] Advertisements announcing such auctions for hard rock minerals appear occasionally in the Northern Miner newspaper. One jurisdiction which uses this approach is the State of Michigan, in the United States. These auctions must be distinguished from those where the assets of bankrupt individuals or companies are sold.

can follow in order to maintain their level of profits. The first is simply to raise the price of their product to compensate for the higher costs. This is perhaps the best solution, since the end-users will be forced to pay the full cost of their consumption. It is, however, not possible for a firm to do this in a competitive industry unless all firms are subject to the same higher costs. The second way is to modify the production, such that each unit of mineral output has value that is higher by an amount that equals the added environmental cost. To achieve this, it is necessary to increase the cut-off grade of the ore mined. In exactly the same way as for the production royalty, valuable mineralized material is left in the ground. The third possible reaction to the imposition of environmental costs is to engage in research and development activities that leads to a reduction in the environmental costs. To do so, however, is not a unique response for the mining industry, but depends on the innovative qualities of the individual mining firm. Warhurst (1991) distinguishes between such firms on the one hand, and stagnant firms on the other. The innovative firms typically innovate in the planning phase of new projects, and push the technological frontier in the direction of lower costs generally (i.e. lower environmental cost *and* lower production cost), whereas the stagnant firms merely respond to environmental regulation by complying, without trying to do so at a lower cost. No indication why implementation of innovative features should be a special characteristic of new projects is given. Indeed, the examples cited by Warhurst does not support this claim.

The ability to realize adequate returns on investment in one of the above ways may explain the concentration of exploration investment in just three countries (Australia, Canada and the United States) in the years since 1970 (Johnson 1990; Eggert 1992). This supports the inference drawn from the concentration of exploration investment (Warhurst 1991; Warhurst 1992), that environmental regulation in the target country is not a serious concern compared to overall political stability.

In economic terms it is common to distinguish between direct regulation, whereby environmental standards are set by government, and various forms of market-based incentive systems

for environmental control. While economists often advocate the use of economic management instruments in environmental policy, it is important to keep in mind that such an approach has its limitations. Emergencies and other situations where swift regulatory action is necessary to protect the environment are best handled with direct regulation (Baumol and Oates 1988).

Generally, market based incentives are advocated on the grounds that they result in superior long-term solutions in terms of economic efficiency. Incentives usually fall in one of two categories. The first is the "charges and standards" type, which basically involve a fee or tax on emissions set (and possibly adjusted) so that a certain environmental standard is achieved. In this way the attainment of the standard can be achieved at something approaching minimum cost to society. The second category of incentives uses the price mechanism in a different way, by assigning rights to pollute, either to current polluters or by auction, and subsequently by allowing the permits to be traded. The latter approach is in some ways more flexible than the charges in its impact on current polluters (Baumol and Oates 1988).

Given the inability of economic incentives to deal with rare or unexpected situations, Baumol and Oates (1988) suggest a combination, with a tax or tradable permit system to deal with what can be termed a "base load" pollution and direct regulation for use in the event of "peaks" in emissions.

The need for a variety of economic and regulatory tools is closely related to the diverse nature of environmental impacts. For mineral production these range from the disturbance caused by exploration teams over the enormous open pits and waste rock heaps of low-grade/high-tonnage mines to the sulfur emissions of base metal smelting processes.

In relation to well-defined and measurable emissions, for example from smoke stacks or within drainage systems, economic incentives are potentially useful instruments. More difficult, however, is the application of economic incentives to some of the other environmental effects of exploration and mining. A typical example of the difficulties is tailings and waste rock disposal.

Mining involves the excavation and processing of mineralized material. In the process, vast quantities of non-mineralized material is removed to gain access to the orebody and this material must be deposited somewhere. Similarly, only a fraction of the ore has any value but all the ore is ground to a fine powder in order to liberate the valuable minerals. The residue from the separation is called tailings, and they too must be disposed of somehow. The usual procedure is to deposit waste in dumps near the mine, a practice which sometimes results in both technical (slope stability) and environmental (acid run-off and landscape damage) problems. Tailings, being suspended in water, are usually deposited in an impoundment area where the water can drain away, again at the risk of contaminating runoff with acid and heavy metals. When problems occur in these areas the cause may be poor engineering, insufficient investment or inappropriate regulation, or a combination of these.

Using economic incentives to deal with this type of problems has not yet been investigated. An effluent fee can be imposed, which would provide an incentive to treat effluents prior to their release. The other impacts, in this example most notably the generation of waste dumps is inevitable unless significantly different mining methods are adopted. Here a shift from open pits to underground mining may hold some promise. However, only where *in-situ* mining is possible can real headway be made in dealing with the areal impact of mines. An example of such methods is direct extraction of coalbed methane with surface disturbance being limited to drill sites.

One often used approach to environmental management of mines is to require the mine developer to post a bond at the beginning of mining, that can provide for the expense of rehabilitating a mining site at the end of mining in the event of the mining company being unable to finance such measures (Warhurst 1992). This practice is standard procedure in Canada and a number of other countries. There are, however, a number of problems associated with using such an approach. First is the determination of the amount of the bond. For a major project with an extended life it will be difficult to predict the requirements for rehabilitation, especially when changing environmental standards are taken into account. Furthermore, the con-

cept of using a bond needs careful analysis if it is to provide the desired incentives for the mining company to minimize environmental impacts over the life of a mine. In principle this would require that the mining company is allowed to keep any part of the bond not used for site rehabilitation.

CONCLUDING REMARKS - MINERAL TAXATION AND ECONOMIC REGULATION

The issue of taxation of mineral rents is paramount in this chapter, with exploration and environmental issues being pushed to the end. Nevertheless, taxation and efficient economic regulation of exploration and environmental protection has an important thing in common.

This is the struggle between on the one hand maximizing the size of the economic pie and on the other hand maximizing the economic benefits occurring to a given group. For example, if the government was only concerned with short term benefits in the form of large revenues, then it could apply high tax-rates, obtain the large revenues but then watch as mines close and investment moves elsewhere. Thus, the challenge for the government as a tax authority is to maximize total revenues subject to the constraint that the total tax-base is affected by the severity of taxation.

The choice of tax instruments also involves the risk to the State of variable tax revenues. This involves a tradeoff between smaller, but stable revenues from an inflexible tax system, and larger but unstable revenues from a flexible system. The RRT involves such flexibility but allows the government to capture more rent in the long run. Furthermore, the fluctuations can be stabilized through the use of funds, as discussed in chapter 9.

The size of the economic pie also depends on how much money is wasted, or dissipated, as a result of inefficient regulations of exploration procedures and environmental protection. For exploration the possibilities of rent dissipation are the greatest in the case of work commitment bidding. However, neither this, nor the misallocation of exploration expenditure as a result of work requirements has ever been analyzed.

The possibilities for rent dissipation also exist in relation to environmental regulation. In this case, however, one must be careful to distinguish between mining firms having to pay some (or all) of the external costs they impose on their surroundings, and doing it in an inefficient way. Getting the most effective environmental protection at the lowest price has always been a central element in environmental economic analysis.

In real life it is not always possible to follow recommendations based solely on economic efficiency considerations. For taxation the adoption of a Resource Rent Tax may be too complicated for some jurisdictions, who may instead prefer to pay the efficiency cost of a royalty in return for immediate revenues. For exploration, traditions in the industry pay an important role. It would thus be distinctly possible to frighten investors in exploration for metallic minerals away by adopting a pure cash bidding approach to leasing of mineral land. A similar problem of implementation occurs in relation to use of economic regulation tools for mine operations. Here the problem is to determine the efficient streams which can be measured and taxed.

In many cases these problems lead back to existing regulatory tools. This does not mean that the discussion has been futile. Rather, realization of the potential problems associated with these forms of regulation, may help designing them to be less inefficient than would otherwise be the case.

5

TECHNICAL MANAGEMENT OF MINERAL ACTIVITIES

The topics covered in the previous two chapters concerned a range of economic issues related to non-renewable resource extraction, ending with some remarks on the relationship between production economics, environmental protection, and the possibility of using economic incentives to reach environmental goals.

Having considerable knowledge of the economic effects of mineral development and of the economic incentive effects of taxes and other regulations does not, however, allow consideration of a complete mineral policy. The tax and other regulations must be comprehensible and consistent, and take into account situations where economic incentives are unable to secure interests other than those of a purely profit maximizing mining firm.

This chapter describes the regulations necessary to manage a mineral industry, with emphasis on the technical, practical and "non-market" (environmental) issues in the mining process. The description is divided in sections along a time line, beginning with exploration and covering development, production and abandonment. Despite the emphasis on technical regulation, the question of economic implications of such regulations will be raised at various points.

The regulations dealt with here are not concerned with regulation of the derived effects of mineral development. These are discussed further in chapter 9.

One of the principal themes discussed below is the question of when environmental values should be protected. This issue is never easy to settle. In principle it can be reduced to one dominated by economic costs and benefits. In that case the stringency of environmental standards depends on the time-horizon adopted in analyzing costs and benefits, and on the period and rate at which future benefits are discounted. In relation to the different environmental impacts of mineral exploration described below, their evaluation also depends on the time it takes nature to reestablish disturbance caused by exploration activity. For the subsequent stages of the mining process, in which extensive disturbance can occur (at least for open pits) it is clear that some permanent changes in the environmental status quo are unavoidable. In these cases the economic valuation of costs and benefits becomes even more important.

From a practical point of view, however, it is clear that while balancing environmental costs and development benefits in each case is highly preferable, such a task may be difficult to implement in practice (see Poulin and Sinding (1993) for a discussion). As a result the second best alternative may be to use a balanced set of environmental regulations. Before embarking on the substance of the present chapter, a brief digression concerning the underlying reasons for introducing regulations at all must be made.

REGULATION, PROPERTY RIGHTS AND EXTERNALITIES

The regulations described in the following sections serve two distinct purposes. One is to allocate property rights to minerals, while the other is to deal with environmental externalities arising as a result of mineral activities.

The existence of property rights in general can be viewed as a necessary institution for markets to function. A model of an economy without property rights has been developed (Bush and Mayer 1974) which shows that an equilibrium is possible. The model also shows, however,

that welfare can be improved by establishing property rights and allocating resources for their enforcement. Thus each individual is better of when he allows his behaviour to be constrained in return for having the behaviour of all others similarly constrained (Cornes and Sandler 1986).

In relation to natural resource issues the establishment of property rights and the special nature of these resources has received considerable attention in recent years (Barzel 1989; Bromley 1991; Libecap 1989 and Ostrom 1990). Here it is important to note the observation of Ostrom (1990), that neither the state nor the market is uniformly able to devise a framework where long-term use of natural resource systems can be sustained.

The market approach involves assigning property rights such that the so-called "tragedy of the commons" problem is avoided. This approach is the implicit recommendation of Coase (1960), who argues that an optimal solution to externality problems can be achieved if property rights are allocated, regardless of the owner. The problem with the "market" approach is that in a number of situations (high transaction costs or many involved parties) it is not possible to ascertain exactly what the property right applies to. This means that, as the unit value of the resource declines, so does the effort expended on defining property rights. In practical terms this means that for resources of low unit value (water for example), property rights are less precisely defined than for a plot of prime agricultural land (Bromley 1991).

The alternative to the private solution is government regulation and resource allocation, as advocated in the famous paper by Hardin (1968). However, while an optimal solution may be possible using this approach, it depends on the information available to the regulator, his ability to monitor events, the sanctions which can be imposed on transgressors, and the cost of operating such a system (Ostrom 1990). The choice is not, however, necessarily between these two extremes. Ostrom (1990) argues that common pool problems may be solved by a mixture of market and regulatory mechanisms, where the latter can be either private or public arbitration or enforcement mechanisms.

For mineral deposits, and particularly for metallic minerals, this approach is similar to the one used by Libecap (1989) to explain the variety of outcomes in different types of resources.

For minerals, Libecap argues that the clarity with which miners observed common pool losses during 1849 California gold rush (where open access and anarchy was the norm) resulted in local contracting to allocate property rights. The features which characterized the smooth process leading to these private mineral rights included large expected aggregate gains from the development of a mining industry, broad access to mineral lands, positive individual shares in aggregate gains from institutional change, few information asymmetries in valuing and assigning individual rights and lack of competing (non-mining) vested interests.

To summarize, the need for defined property rights arises from the needs of the market and the common pool nature of natural resources. A set of rules can evolve under favourable conditions, as described by Libecap (1989). The problems arise when competing interests are important. These can be diverse but can be considered together as they all arise from the external effects of mineral activities.

This brings us to the other reason for applying rules and regulations to mining. This activity has external effects which must somehow be dealt with. The government regulation or market operation discussion applies here, but only leads to one or more of the standard prescriptions of environmental economics. However, the areas where tools other than traditional regulation can be applied in relation mining are very few and very little research has been conducted on how to use economic tools to deal with mining environmental problems.

EXPLORATION

The exploration process starts when someone begins to think about finding a mineral deposit. For the individual exploration firm the process of discovery involves definition of fundamentals such as the commodity(-ies) to look for, geological environment in which to do so, and selection of regions where such environments exist. Some of these fundamentals may be given as part of corporate policy. In addition, the selection of a target area depends on geology, available infras

tructure, and a component which is a function of the economic, regulatory and political conditions in the target area.

For a government wishing to attract investment, infrastructure as well as economic, regulatory, and political conditions are within its control to varying degrees, although improving infrastructure is a much more long term undertaking than improving the regulatory package offered to investors. In the present section we examine the technical elements in the package which have direct bearing on the exploration phase.

Land use planning and land access

Investment in exploration is in many ways an irreversible or sunk cost. The information acquired is closely related to the tract in which it was collected. The close relationship between information and location means that tenure, and the possibility of being able to extract any discovered minerals, is important . At the same time the problem facing mining firms now, and in the future, is that mining is an activity which must compete with alternative land uses. This contrasts with earlier times, when mining was usually considered the highest and best use of the land - and permission to mine was not an issue.

In many industrialized mining countries recent years have witnessed the final demise of the preferential status of mining as the most valuable land use. One of the most compelling examples of this has been the creation of a "World Heritage site" in the Tatshenshini-Alsek River area of NW British Columbia, in an area with high mineral potential, no previous development, and one well explored major ("World Class" according to some) copper deposit (CORE 1993). One of the most important lessons which can be drawn from this case is the long time it took from the original staking of the Windy Craggy claims to the emergence of the environmental

debate which led to the creation of the World Heritage Site[22]. Thus it was only when the threat of mining became imminent that action was taken.

The insecurity surrounding many projects as a result of such events highlight the reduced value of traditional mineral rights. For the small and new mining country wishing to attract investment, it is important to send a signal to investors that mineral rights are very secure once assigned, and that environmental policy will not be used to block projects *ex post.*

Part of the solution to the problems exemplified above is conceptually simple, but possibly difficult to implement. Mineral rights should be issued only in areas where the government is fully committed to protecting these rights. In areas with significant other values, which cannot be protected without total exclusion of mineral activities, access should be denied with such clarity that there is no incentive to speculate in a reversal of policy.

The problems of implementation are admittedly severe. First is the fact that government commitment may last only until the next election. The uncertainty about commitment can be reduced, if there is broad political agreement about such a policy. The second problem is one of information availability. For a land use policy of this kind to be credible, it is necessary that the government (and the public as well) is well informed about the environmental values which necessitate a ban on mineral activity. Thus, an approach of this kind may only be possible in countries or regions where the information base on these matters is already well established[23]. The various mineral resource assessment techniques, especially those relying on multivariate

[22] The claims were staked in 1958, but the exploration which led to the mining proposal and thus to the demands for denial of permission to develop and mine, was only initiated by Geddes Resources from 1981 onwards. The decision to create a World Heritage site was made in the summer of 1993.

[23] The example from British Columbia, showing the delay from the recording of the initial mineral right, and the emergence of the problem when mining becomes a real possibility, is applicable in all cases where alternative land uses (parks and wilderness areas) are imposed on top of existing rights. The more aggressively a government pursues protection policies, the more adversarial will be the attitude taken by owners of existing rights. The implementation of alternative land use decisions based on the turnover rate of mineral claims and the probability of discovery is discussed briefly by Poulin and Sinding (1993b).

geostatistics (Harris 1984), and the discovery process model (Barouch and Kaufman 1976) may be useful in estimating the mineral potential of an area. However, such estimates needs to be supplemented by estimates of the value of other environmental assets.

Location, position and recording of titles

The legal right to mineral deposits is a central element in any project and the system under which such rights are issued is very important for how investors perceive a country as an investment target. In order to understand various types of mineral rights it is necessary to examine briefly the traditions in the area of mineral title disposition.

Initially, a distinction must be made between on the one hand Anglo-Saxon common law tradition, and on the other hand Roman and continental (i.e. European) civil law. In the Anglo-Saxon tradition the subsurface and surface estates follow one another. In contrast, the Roman law tradition separates the two estates, and commonly vests the mineral estate in the Crown or state. However, present-day mineral laws are to some extent a mixture of the two traditions, and the developments they have undergone over the centuries.

As in most areas of law, the distinction between Anglo-Saxon common-law tradition and continental civil (Roman) law tradition also applies in mining. The Anglo-Saxon approach has been noted above. The Roman Law tradition includes two important aspects not found in Anglo-Saxon legal tradition. The first is the concept of "regalian property". This implies that kings and other potentates reserved for themselves the right to gold, silver and precious stones found within their respective realms. The second concept is the "res nullius", that some things are not owned by anyone until found and appropriated by someone. The regalian property as used in central Europe was gradually expanded to include all sub-surface minerals, and is the precursor for modern-day state ownership of mineral resources (Kuehne and Trelease 1984).

The development of Anglo-Saxon mineral law was marked by the gradual adoption of some of the principles of Roman and continental legal tradition, and a movement away from the combined nature of the surface and mineral estates. The *res nullius* is evident in the "free miner"

concept, and also in the widely used claim staking approach to mineral title disposition used in the US, Canada and Australia. A number of other features of modern Anglo-American mineral law can be traced to this continental influence, including the concept of extra-latteral rights ("the law of the apex") (Leshy 1987), and many standard terms such as "drift", "stope", "strike", etc. (Kuehne and Trelease 1984).

Despite the fact that the *res nullius* still exists, the ability to stake and record a claim in countries in the Anglo-American tradition applies only to certain lands. On privately owned land the original unity of the two estates may remain, the owner may have created a mineral estate in another person or may have sold the surface right while reserving the mineral estate for himself (see figure 5.1.). The creation of lesser property rights by "leasing" the minerals to an operator is also a possibility (Kuehne and Trelease 1984). For lands owned by the state, access to claim staking still exists in some countries (the US. and Canada). Staking can, in principle, be done on any Crown land in Canada, or any federal land in the United States, unless the land has been withdrawn (i.e. for urban areas, parks, reservations etc.)

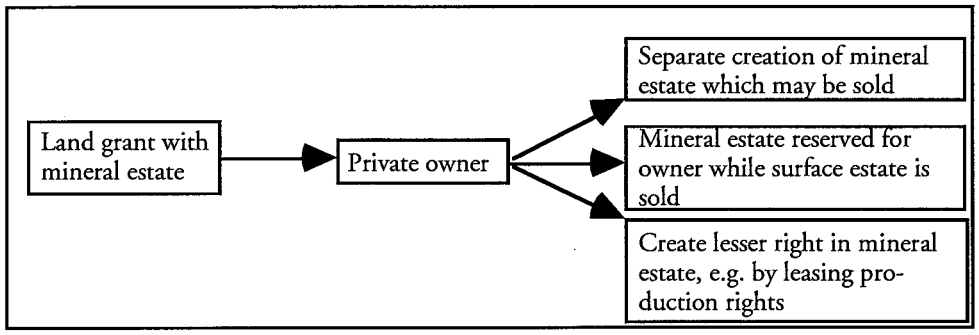

Figure 5.1. Mineral titles when surface and mineral estates are granted together.

One of the interesting contrasts to the above description is the Australian procedure. In the states of Australia the practice of including minerals in Crown land grants was eliminated in the last quarter of the nineteenth century. Some mineral rights granted earlier have even been re-expropriated (Crommelin 1988). A further feature which distinguishes Australian mineral legislation from the Anglo-American tradition is that in many states the power to grant mineral

rights is fully discretionary, as seen for example in the Western Australia Mining Act[24]. This in effect moves the Australian procedure closer to the "regalian property" approach. A similar trend for Canada and other common law countries has been noted by Eggert (1992).

The trend in common law countries towards regalian or state property in minerals (Eggert 1992) means that an alternative to the disposition of combined surface and mineral rights is necessary. Figure 5.2. outlines a considerable range of options. It should be noted that these are all equally applicable to allocation of mineral rights within a state property/regalian property regime. The term "title" used above does not imply anything about the quality of the right allocated to the holder. The most proper description is to refer to the title as a contract between the [present] owner of the mineral estate and another party, who either buys the entire mineral estate within a defined area, or the right to extract minerals under specified conditions.

The distinction between regalian and *res nullius* property regimes matters only if a large fraction of state or Crown land has been transferred to private owners. If such a transfer has not taken place the distinction is irrelevant because the state owns both surface and subsurface.

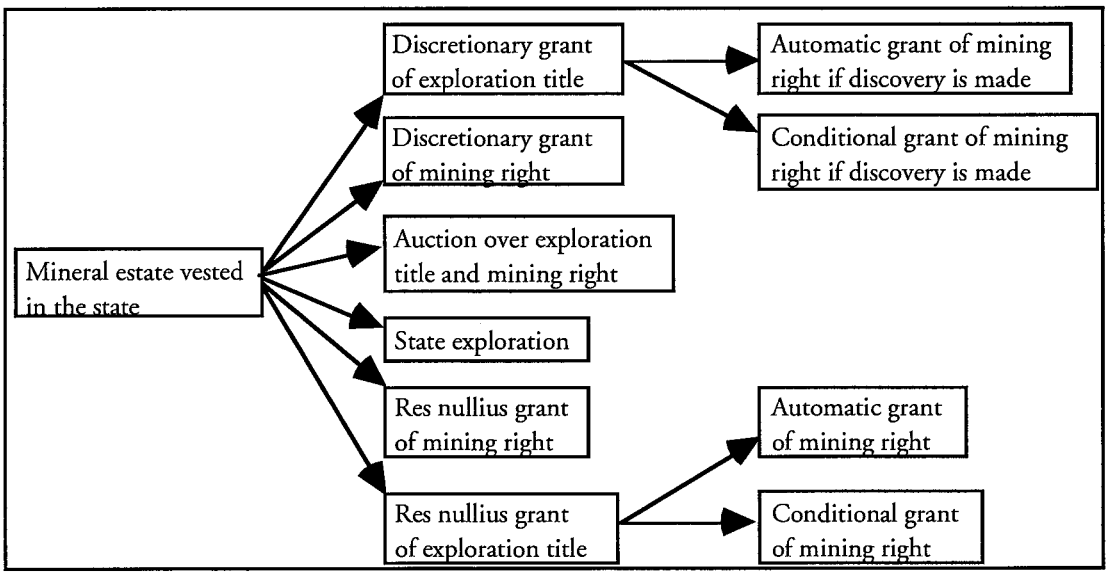

Figure 5.2. Mineral titles when mineral estate is vested in the state (regalian) property.

[24] According to the *Mining Journal* newspaper of July 16th, 1993, the Western Australia Mining Law is currently undergoing reform. The observation applies, however to several other states, including Tasmania, Northern Territory and New South Wales.

Exploration titles and control over marginal deposits

A special aspect of mineral titles is the way they treat properties, or cases where exploration has indicated an anomaly or mineral occurrence which is not currently economic. In such situations the investor may want to retain the right to mine the deposit at some future date, if commodity prices or extraction costs so favour.

Most mining laws do not have provisions which cover such cases specifically. The Canadian jurisdictions examined (British Columbia, Ontario and Quebec) are examples of this. For most of these, however, the tenure can be maintained for a long time by the accumulated value of exploration work carried out by the holder of the title. Australia, in contrast, provides two examples of specific regulation of this issue. In Western Australia the *Mining Act 1978* allows exploration licenses an exemption from the normal work requirements in a number of cases, for example when the title is in dispute, when time for further investigations is needed, when a deposit is presently uneconomic, or when the holder has problems obtaining the necessary permits[25]. Similarly, the Northern Territory of Australia has included a special "Exploration Retention License" in the Mining Act in order to deal with presently uneconomic deposits[26].

Regulation of the exploration process

Distinct from the matter of mineral titles and the way they are allocated is the question of regulating how prospectors should go about their work of discovering mineral deposits. To provide the foundation for the mineral policy design for Greenland in chapter 8, it is necessary to discuss briefly the possible impacts of mineral exploration activities. These can be divided into three main categories, surface disturbance (on site and for accessing the site), environmental problems on site (storage of supplies and disposal of waste materials), and general impact of exploration activity on plant and animal life in an area.

25 Western Australia Mining Act 1978, section 102.

26 Northern Territory of Australia Mining Act section 38.

Surface disturbance may occur when more advanced exploration involving diamond or reverse circulation drilling, trenching, and bulk sampling from shallow pits is undertaken. To this category must also be added the use of blasting to obtain fresh rock samples or to gain access in other ways, and the construction of underground access to an orebody. These can all be major impacts if sites are not reclaimed. It is not clear, however, how far reclamation should proceed. One thing is to fill in trenches and pits, but more difficult, and itself a matter of degree, is the question of whether disturbed areas should be revegetated.

Another type of surface disturbance can be involved when roads and culverts are constructed for the purpose of establishing road access. In this case there are two options. One is to remove the road which involves the risk of disturbing an even larger area than occupied by the road itself. The other is to leave the road in place. This is a particularly relevant option in cases where the road can be used to access more than one exploration site.

The operations involved in mineral exploration may also have the potential for other environmental impacts at the exploration site. These are related to the storage of supplies (primarily fuel and chemicals), and the disposal of waste (non-combustible). The possible regulatory responses range from non-action to rules prescribing the use of approved containers for supplies, the nature of storage sites and requiring total removal of all wastes, garbage, sludge etc. (burial is an option but this involves surface disturbance).

The final problem associated with the exploration phase is referred to as "general environmental impact", for want of a better term. This refers to the impact on plant and animal life of the presence of humans looking for minerals. These impacts depends on the extent and intensity of activities. Most are, however, highly localized as a result of the spatially limited extent of an exploration area (in most cases) and the fraction of sites explored intensively (e.g. by diamond drilling) is very small relative to the total number of sites examined in an exploration program.

The actual regulation of the mineral exploration process varies from one jurisdiction to the next. In some cases regulations are primarily concerned with occupational health issues, as seen in the case of British Columbia, a province in Canada (Resource Management Branch 1992)[27]. With the exception of actions to be taken if acid generating rocks are encountered, environmental aspects are primarily mentioned in section 10.1.1 of the Code. This section emphasizes that plans filed for approval pursuant to section 10[1] of the *Mines Act*[28] must show how reclamation is expected to proceed

In the case of Ontario, another Canadian province, the most recent revisions to the *Mining Act*[29] includes regulation of "advanced" exploration projects, defined as those activities which resemble actual mining operations. This type of activities require the operator to give notice to the proper authorities, and to submit a closure plan to the Director of Mine Reclamation.

The Mining Regulations 1981 of the *Western Australia Mining Act 1978* are considerably more brief on the matter of exploration regulation, stating that holders of mining tenements[30] *"shall not allow detritus, dirt, sludge, refuse, garbage mine water or pollutant from the tenement to become an inconvenience....to the public..."*[31].

The Northern Territory of Australia is more explicit. Section 24 of the Mining Act specifies that licensees must notify the proper authority in advance when an exploration program involves substantial surface disturbance, and must comply with directions issued by that authority. Section 24 also specifies that notice must be given, and directions complied with, regarding camp location, disposal of camp waste, discovery of water underground, installations and historic sites[32].

27 The rules are found in part 11 of the health, safety and reclamation code for mines in British Columbia.

28 Statutes of British Columbia, Chapter 56.

29 Revised Statutes of Ontario, chapter 268.

30 A tenement is a common term for various types of mineral title in Australia.

31 Western Australia Mining Regulations section 98. The following section of the regulations adds that holders are required to make adequate provision for preservation of decency on the tenement.

32 Generally much more stringent limitations apply in Australian conservation areas. The important thing to notice, however, is that exploration is allowed at all. This also applies in the case of Tasmania and the logical consequence is that mining is possible in conservation areas, at least in principle.

Still more detailed regulations are found in Tasmania, the smallest of Australia's states. These are issued administratively under the power given in section 15[1] of the *Tasmania Mining Act 1929* (Tsamenyi 1989). The general environmental conditions imposed on exploration includes the following:

1. Written permission to use mechanical excavators must be obtained;
2. Filling in of non-required excavations is necessary;
3. Approval to light fires must be obtained;
4. No interference with aboriginal and historical sites or objects is permitted;
5. No interference with native fauna and bird life is permitted;
6. Surface area disturbed must be minimized and grasses and soil removed must be replaced;
7. Any proposed construction of roads or airstrips must be reported;
8. All waste and rubbish must be removed or buried.

These regulations are further expanded where mineral leases are located in conservation areas, and the regulations are considerably stricter (Tsamenyi 1989).

Exploration work requirements

The matter of required exploration work was discussed from an economic point of view in the previous chapter, but little was made of the actual size of work requirements in monetary terms. The following table gives an idea of these requirements in some of the Canadian jurisdictions mentioned elsewhere in the text. These are considered fairly representative of the terms one is likely to encounter.

TABLE 5.1. MINERAL EXPLORATION REQUIREMENTS IN CANADA NORMALIZED TO C$ PER STANDARD UNIT (16HA)

Year	1	2	3	4	5	6	7	8	9	10
British Columbia	64	64	64	128	128	128	128	128	128	128
Ontario	0	400	400	400	400	400	400	400	400	400
Quebec	250	250	250	250	250	250	375	375	375	375

Source: British Columbia Mineral Tenure Act Regulations, Section 19, Ontario Regulation 116/91, Section 2, Quebec Mining Act.

These levels of required work can be contrasted with the amount required in Western Australia. There the minimum amount of work is A$300 per square km.[33]. In the Northern Territory of Australia the work requirement is fixed in individual exploration licenses[34] and no information is available on their size.

REGULATION OF MINE DEVELOPMENT AND PRODUCTION

Following the discussion above, the fact that mineral exploration in an area has been allowed, must normally be taken to indicate that mining activities are considered an acceptable activity, possibly subject to conditions laid out when exploration title was obtained. This must, in principle, mean that mine development can proceed subject to current rules and regulations.

The decision to allow mineral exploration is not necessarily identical to complete *laissez-faire* policy. The actual process of mine development may still be regulated in order to deal with various types of external effects associated with mines. These are not only those associated with environmental impacts, but can also be caused by socio-economic impacts.

The present section examines three phases of mining, development and project approval, operation and monitoring and, finally, closure, site abandonment and long-terms monitoring. For the discussion of problems associated with project approval procedures an example drawn from the Province of British Columbia is used extensively.

Project approval

The regulator dealing with one or more applications for permission to develop a mine is faced with two options. He can devise a regulatory framework specifying precisely what criteria any project must meet, await applications, and check whether or not they are in compliance. The

33 Western Australia Mining Regulations, Section 21.

34 Northern Territory of Australia Mining Act, Section 24.

problem with detailed regulation is that such a system may have difficulty in dealing with widely differing projects unless all possible situations have been taken into account when regulations were designed. The extent to which this approach is possible and reasonable depends on many factors. The most important is probably the size of the industry in question, the amount of knowledge and information the regulating agency has accumulated, and the efficiency of the method relative to other approaches.

Alternatively, the regulator can adopt a case-by-case approach, setting out only general guidelines for application documents, and then use a three-sided process to define precisely what must go into an application document. An example of this approach is provided by the British Columbia Mine Development Assessment Process[35], as described below. This example may not be one worth following, but it serves to indicate the issues involved in the project approval phase.

The British Columbia process consists of two levels, one for "simple" projects, and an additional one for "complex" projects. The first level consists of 3 phases. First the *pre-application* phase is used to define the terms of reference to be followed in the application for a certificate allowing mine development. Then comes the application phase, in which the applicant tailors his document to the terms of reference already defined. The third phase involves a government decision on the application. The first phase requires the submission and publication of a *prospectus* containing basic information on the project, organized along the following lines:

1. Corporate information and property history;
2. Geology, reserves, proposed pilot operations, production levels and reserve life;
3. Nature of workings (pit or underground, location, design etc.);
4. Location, design and size of mine rock dumps, tailings disposal areas, and ore stockpile areas;
5. Ore processing facilities (crushing, milling. and concentration facilities);
6. Infrastructure (site layout, power supply, site access, housing);
7. Development timetable;

[35] The process, described in the document "A guide to the review and certification of mine developments" published by the B.C. Ministry of Energy, Mines and Petroleum Resources and the Ministry of Environment, Land and Parks, is regulated by the Mine Development Assessment Act of 1990, S.B.C Chapter 55.

8. Summary of environmental and socio-economic baseline information and proposed study program;
9. Review of likely environmental and socio-economic impacts;
10. Proposed consultation program.

The consultation at this level is intended to identify possible information gaps prior to the submission of a formal application. In the second phase the information already recorded in the prospectus is supplemented by additional information on project impact:

11. Baseline information[36] from which potential impacts can be determined and impact management strategies developed;
12. An assessment of environmental and socio-economic impacts and a plan for mitigation of identified impacts;
13. Plans and strategies for public consultation;
14. List of all anticipated permits, approvals and licenses (provincial and federal).

The full application must be made available to the public, and this fact must be advertised, all as part of the consultation process. The third phase is the review by a management committee appointed by the two ministers (i.e. mines and environment). The committee must recommend to the minister one of four options:

A. Refer the application to an independent assessment panel (i.e. take it to level 2);
B. Accept the application and issue Mine Development Certificate which allows the applicant to proceed with obtaining permits, licenses etc. The certificate identifies the terms and conditions under which it is issued, including any follow-up program and/or mitigation measures to be implemented in connection with the development;
C. Return application for upgrading;
D. Reject application.

[36]Environmental field information must cover at least one full year, and possibly more, in order to be sufficiently representative.

The second level of the assessment process is activated if a project application is referred to a panel review. This involves an extensive further round of public consultation using a choice of information programs, negotiation, mediation, informal hearings and formal hearings. Based on these activities, the panel makes a recommendation to the minister(s), who must then reject or accept the application. In practice, the panel review must often take place as a joint review with the federal government. This additional level of review (the Environmental Assessment and Review Process) is activated whenever a project may have a significant impact on an area of Canadian federal responsibility.

The procedure involved in the case of the British Columbia Mine Development Review (MDR) is very long, especially if the second level is activated. Following the discussion in the section on land use planning, blocking projects at the development stage is logically inconsistent, potentially very wasteful, and may lead to significant distortions in the allocation of exploration expenditure. The question is, however, why the review occurs at this late stage in a project history.

One factor explaining the Mineral Development Review approach is the lack of adequate land use planning in earlier times. A clear statement of where development of mines is desirable as a matter of principle would help direct exploration investment to those areas where development is certain to be allowed if a discovery is made.

A second factor is lack of information. The land use planning required is based on information which, if not available, must be obtained when development is proposed. This highlights the problem associated with any planning associated with mineral development: the highly specific nature of all exploration information. If information is collected in advance of exploration, in order to be prepared, there is a high risk of it being redundant where there are no mineral deposits to be found. On the other hand, the alternative is to submit all projects to the risk of being blocked, if *post-discovery* information indicated that a mine should not be built.

The MDR process described above also has another inherent problem. This is the very high degree of public involvement in the process. While this may to some extent be a special

Canadian phenomenon, it reflects the fear that the political and administrative system of government is unable to adopt optimal solutions. The answer in the Canadian approach is additional layers of "public consultation". Despite its ability to supply decision-makers with information about different views on a resource development the consultation process may give the public a false feeling of having influence on decisions.. The consultation process can also become dominated by individuals and groups with narrow special interests, leading to what is essentially rent seeking activities (Poulin and Sinding 1993).

Apart from the environmental perspective, the Health, Safety and Reclamation Code for British Columbia, as well as the Mine Management Act of Australia's Northern Territory exemplifies the wide range of practical issues involved in the development phase. These include mine design, industrial hygiene, personnel safety, use of explosives and various types of equipment, as well as the duties of both the mine manager and employees and inspection, testing and approval procedures.

Regulation of mine production

Regulation of mine production involves two separate aspects. One is related to production itself, the other to environmental protection. For production the issue is whether a regulator should have any powers to influence production decisions, especially mining rate and cut-off grade.

There are two arguments in favour of providing a regulator with such powers. The first is related to the regional development aspect of mining. From a government point of view it may be desirable to extend the life of a mine in order to justify various public investments, or to preserve jobs. The problem faced by government is that mining firms frequently do not define ore reserves beyond a 10 year planning period, while many public investment projects (infrastructure, health care, schools) have considerably longer life spans. This provides an in-

centive for a regulator to demand an extension of mine-life by specifying production levels and/or cut-off grades lower than those preferred by the mining company[37].

The argument is questionable, however. The business of mining is characterized by considerable variability, especially in mineral commodity prices. These translate into fluctuations in the fortunes of mines, especially if they are only marginally profitable. These fluctuations may then lead to "boom and bust" cycles in mining communities, causing temporary hardship. These problems may be temporary, but will eventually emerge as the ore reserves of a mine are depleted. The question is whether regulation of mining rate and/or of cut-off grade will alleviate the "boom-bust" problem or the depletion problem. Given that such regulation has the potential of being inoptimal (not profit-maximizing) for the mining firm, it is likely that firms will not invest in inframarginal projects, if such regulations are in force.

The second argument for giving a regulator the power to limit production is based on environmental considerations. The level and impact of a mine may depend on the level of production of various types of waste. To the extent that emissions are a function of the level of production, and when the environmental impact of a mine depends on the emissions, then regulating mine production may be necessary. The bottleneck here is the carrying capacity of the environment, and the regulative approach needs to share this capacity among all who wishes to produce. This problem is faced by all human activities and is highly dependent on how environmental regulation is approached generally.

The conclusion must be that if, for some reason, governments choose to subsidize mine projects to a significant degree, they become partners in the project. They can then reasonably pursue other objectives than profit maximization. In general, however, it is not optimal to interfere with operations.

37 An example of this is the development of the Nanisivik Mine described in chapter 9. There the Government of Canada insisted on a longer planned mine life as a condition for providing subsidies for infrastructure (Wojciechowski 1982).

CLOSURE OF MINES AND ABANDONMENT OF MINE SITES

When a mine closes, the reason is always lack of ore in some form. The events resulting is this lack, can be many and varied, ranging from true exhaustion of reserves to cost increases, price declines, accidents, and political upheaval, which may occur separately or in conjunction with one another. The key feature is that change the basic operating parameters of the mine, and thus the quantity of ore. The closure may be permanent or temporary, again depending on what combination of events precipitate it. In both cases, however, a number of regulations are relevant. The following sections examine three aspects of mine closure: temporary closure, during which the mine is put on a care and maintenance basis, permanent closure and site reclamation, and long-term management of abandoned sites.

Temporary mine closures

Mining is based on the presence of mineralized material in sufficient quantity and quality (grade) to allow profitable extraction to take place within a certain time horizon. The economics of a mine depends on the price of mineral outputs and the cost of extraction. All of these factors vary over time. As a result the definition of valuable ore and worthless waste also changes over time. In some cases the movement of commodity prices and extraction costs conspire to move large fractions of the ore reserves into the waste category. When this occurs, the mining firm is faced with three options. If it is possible to respond to lower prices or higher costs of supplies by improving productivity, then the mine may both recover "lost" reserves, and be better placed, if and when prices increase. In some cases, particularly in the short term, a mine will not be able to react in this way. It can then respond by limiting losses by closing the mine operations until prices recover. This is not a cost-free exercise, but may in some cases also allow time to restructure production and increase productivity or, simply, await better prices. For the regulator who has made sure that provision has been made for permanent closure, the goal should be to minimize the cost of temporary closures.

Permanent closure, reclamation and long term monitoring of abandoned sites

In cases of permanent closure of mines, environmental aspects dominate the regulatory picture. As mentioned in the examples given above, reclamation issues are often part of the regulations covering the exploration phase. That trend continues into the production phase. As above, the following description is based primarily on three examples for which data are available: British Columbia, Ontario and Tasmania.

The exception to the environmental preoccupation in the case of British Columbia is the requirement that in case of permanent mine closure, all mine openings must be made safe against inadvertent access. Otherwise environmental protection dominates. The chief concern is reflected in section 10.1.2[4] of the British Columbia Code, which requires the mine manager to submit

"a program for the protection and reclamation of the land and watercourses during construction and operating phases, with particular reference to

(a) environmental monitoring and surveillance,

(b) a detailed reclamation program, including research, for the next five years....."

Section 10.1.2[5-6] continues the list of what the manager must submit:

"[5] a conceptual final reclamation plan for the closure or abandonment of the mining operation..."

"[6] an estimate of the total cost of outstanding reclamation obligations over the planned life of the mine, including the cost of long term monitoring and abatement"

The range of possible content of closure and rehabilitation plans can be extremely wide, as shown by the guidelines for mine rehabilitation published by the Ontario Ministry of Northern Development and Mines (1992). These guidelines give a very good impression of the content and function of such plans. The three objectives of a rehabilitation can be summarized under

the following headings, protect public health and safety; alleviate or eliminate environmental damages, and allow productive use of land in its original condition or in an alternative use.

The key factors which determine whether these objectives can be achieved are physical and chemical stability of physical structures remaining after mine closure. The Ontario guidelines (Ontario Ministry of Northern Development and Mines 1992) go very far in terms of ensuring protection in perpetuity by stating that, ideally, physical structures must be able to withstand erosion of any kind, regardless of how extreme conditions may be. This requirement is expressed in the direction that a rehabilitation plan must consider:

1. Naturally occurring physical hazards;
2. The level of environmental impacts;
3. Expected subsequent land use.

Finally the guidelines consider three types of design. The "walk away" design implies that no subsequent work or monitoring is required. The "passive care" design implies that only minimal and occasional maintenance and monitoring is necessary. The "active care" design category indicates that ongoing operation of abatement measures and constant monitoring and maintenance is necessary.

The elements of the Ontario rehabilitation system briefly noted above are remarkable in one way: They do not seem to take into account an overall economic view of the need, desirability or otherwise, for rehabilitated sites. The need is partly explained with reference to public health and safety, but that only applies to part of the impacts of mines. The other arguments, level of environmental impact, and expected subsequent land use, are different in the sense that the effects of mining are externalities imposed on public, and thus the problem is one of valuing the associated economic loss.

All these programs and estimates are to be submitted as part of an application for a permit to mine in British Columbia. Such a permit is issued by the Chief Inspector of Mines under sec-

tion 10[3] of the *Mines Act*[38]. A permit may specify that it is a condition for the permit that the mine owner, agent or manager gives security *"for an amount considered necessary to carry out mine reclamation" (Mines Act, Section 10[4]).* To secure that reclamation is carried, out the owner may further be required to add to the security already given, on an annual basis. The 1989 amendment to the Ontario Mining Act basically takes the same approach, although more emphasis is devoted to bringing existing operations under the reclamation provisions. In Tasmania elements similar to those described are used, but are implemented administratively under the general power of the minister to include conditions in mineral permits (Tsamenyi 1989).

ON REGULATION DESIGN AND THE ENVIRONMENTAL COSTS OF MINING OPERATIONS

The question of how technical regulations related to environmental protection are designed, and where in the overall regulatory structure they are placed, is a matter of considerable interest. It has been addressed by Tsamenyi (1989) in a specific context, but a number of general points of interest emerge from this discussion. These are examined in the first section below.

Environmental regulations in most cases involve additional cost to the mine operator. Apart from the advantage of designing environmental regulations such that the most environmental benefits are obtained at the lowest cost, the special nature of mining means that the costs of environmental compliance involves the regulator in a difficult tradeoff between revenues and environmental quality. This issue is the subject of the second section below.

Environmental rules for mining and their place in the regulatory structure

The discussion of environmental issues by Tsamenyi (1989) in relation to his review of the *Tasmania Mining Act 1929* provides a good framework for addressing the problem of how environmental aspects of mineral activities are best dealt with. Three different options are possible:

[38] Mines Act, S.B.C. 1989, Chapter 56.

1. Include detailed environmental regulations in the mining act;
2. Include only general environmental regulations, and give the minister discretion in detailed regulation;
3. Place environmental regulations in the relevant environmental protection legislation.

The three options reflects the dilemma faced by a regulator over the proper place of environmental regulation of mining activities. Detailed regulation have the advantage of placing all project under equal constraints, they give investors detailed information in advance of any investment, and ministers and civil servants have little or no discretion. On the other hand, the variability of projects, the possibility of over-regulation (as the rules must be able to deal with all possible cases), and the more frequent (relative to general regulations) need to amend a highly detailed set of rules, are negative aspects to consider.

Using general rules combined with administrative discretion is a more flexible approach, although it introduces a higher degree of uncertainty about the magnitude of environmental costs. The extent to which this is a problem depends on how much of the regulatory burden is decided on an individual project basis, and how much is specified in rules issued administratively under the discretionary powers of the minister.

The third possibility is to place all types of environmental regulation under the same legislation. This still leaves the problem of detailed vs. general rules, and may add internal communication problems between government departments. On the other hand the possible objection that environmental laws are unsuited to deal with the special case of mining does not hold.

Regardless of how management responsibility is placed, the regulating agency responsible must take into account that it can be manipulated by special interests. For example, the environmental agency may be influenced by preservation groups, while the mining agency may be influenced by the people from the mining industry, with whom it is in contact. The degree to which such "regulatory capture" is a problem depends on how much actual influence interest groups have on the policies of the respective ministries, and that in turn is related to the scope the ministries have to influence decisions. If they are allocated wide administrative discretion,

and have a tradition for impartiality, there is no real problem. If, however, bureaucrats are not impartial, then discretionary powers may not be preferable to detailed regulation.

With these remarks in mind it must be said, that the choice between alternative locations for environmental regulation of mining, and between detailed and general regulations depends on the circumstances in each case. If the mining industry is relatively small, then the special nature of the industry indicates that environmental regulation should be placed under the mining legislation. If the industry is large, regulation should be part of the general environmental protection legislation. Except in rare cases the combination of general rules in the legislation, specific rules determined administratively and some discretion in individual cases would be the most flexible approach which did not prevent investors from having a good idea of cost determined by environmental regulation. Where an individual approach is adopted, the "Environmental Impact Assessment" (EIA)(option 7) becomes an important tool in determining project impacts and the regulatory responses. In this context it should be noted that an "EIA" can be many things, and that its content must either be specified generally or individually in each case.

Environmental costs and benefits in mining

It is a well known fact that private economic activity can impose unwanted costs on other people. These costs are external to the decision unit, and will not be taken into account in its actions unless it is forced to do so. Environmental regulation is one of the ways in which external effects are re-imposed on their originator.

Regardless of their form the various possible environmental regulations are all characterized by the fact that they impose an additional cost on mining firms relative to situations without regulation. Regulations are introduced to make the mining firm pay the full (or at least more) of the social cost of their operation.

The problem facing government is that on the one hand it seeks to impose environmental regulations, while on the other hand those regulations may have a strong impact on the reve-

nues resulting from taxation of mineral rent. Restrictive environmental policies essentially involve an internalization of external costs, such that the unit production costs reflect the full social costs. However, higher cost can transform a mineral deposit into a worthless occurrence of mineralized material. Alternatively it may reduce the amount of mineral rent which is the base for mining tax revenues. The reason for this is that the principal mineral commodities are traded in competitive markets where the individual producer does not have the power to influence prices (Slade 1991). This means that producers can not pass on their additional costs to consumers, but must instead take the cost out of profits. Given that investors are unlikely to accept a lower rate of return, this in turn means that each mine will have to mine ore with a higher grade, in order to cover environmental costs and a normal rate of return (Poulin and Sinding 1993a).

This special characteristic of mineral resources comes on top of the general need to be informed about the environmental loss resulting from unregulated economic activity. The problem facing an environmental regulator is to determine how strict regulations should be. In order to do so some way of quantifying the loss associated with development is required. The general approach presented in chapter 3 involves both benefit and cost of development, as well as the benefits which could have been enjoyed if development were not to occur. Thus, the problem facing a regulator is how to value environmental benefits which are typically not traded in any market. Chapter 3 suggested that methods do exist, and are applied in some cases. In relation to mining, the information required is an economic valuation of the changes in nature a mine creates, both temporary and permanent. Once it has been determined what the cost-benefit equation looks like, it is then possible to determine how the unacceptable impacts are to be eliminated. The solution presented above is not, however, explicit on the manner in which unacceptable externalities are to be internalized.

Unfortunately, due to the uncertainty associated with exploration, lack of information on those locations where mineral deposits happen to be discovered frequently means that determination of environmental values must take place after discovery, thus basically challenging

the right to develop a discovery which we prefer for other reasons. This information problem brings us back to the land use planning approach discussed in the beginning of this chapter. The possibility exists under a zoning scheme, where different levels of environmental stringency applies, to provide investors with a reasonable quantity of information on costs related environmental compliance.

CONCLUDING REMARKS - THE DETAILS OF MINING REGULATION

In contrast to the preceding two chapters, the emphasis has been much more on details and on procedures. One of the most important aspects is the link between investment in exploration and mineral titles. It is clear that if mining title is to be a useful instrument it must give the holder security and protection. If the right is subsequently encroached upon for external reasons a good case for compensation may exist.

The essential problem is that the use of land for mining is no longer taken for granted, while at the same time the problem of many mineral titles issued before other resource values became prominent remain. The strategy of the future seems to involve a heavy emphasis on land-zoning, attended by explicitly stated guidelines on the level of environmental protection applicable in a given zone. This will allow investors to base their decisions on facts rather than on conjecture about the severity of future regulation.

Much of the discussion of exploration regulation, development devices and closure plans is based on environmental protection requirements. The project review process, in particular, serves to define environmental constraints during and after mining operations. Some of the overall issues about mining being allowed could be resolved before exploration begins by adopting land use zones. It is unlikely, however, that all details can be dealt with in this way. Therefore, project reviews may still have a function in determining exactly what quantity of external effects is acceptable to the mining firm, the government and other major interested parties.

Both here, and in relation to the taxation area described in the previous chapter, it is highly relevant to mention two rules of conduct which are applicable to any attempt to change a policy (Tussing 1984):

1. *"Don't mess with the rules without a very good reason";*
2. *"If you've got to mess with them, do it and get it over with; but don't KEEP messing around".*

6

MINERAL VENTURES IN GREENLAND

Some primitive forms of mining have taken place in Greenland since 2-300 BC., when the Dorset culture developed the use of iron tools. Their source of iron was the iron meteorites which could be found on the sparsely vegetated ice-free surface (where larger blocks are brought to the surface by the action of permafrost). Later, in the 18th and 19th centuries, European explorers were often drawn to Greenland by rumors of rich mineral opportunities, but they were all disappointed (Lidegaard 1991).

It was only from the middle of the nineteenth century that mining, in the ordinary sense of the word, came to Greenland. This was at the famous cryolite deposit in Ivittuut in SW Greenland. In the 20th century, other significant mines followed: coal at Qutdlissat on Disko Island, lead and zinc at Blyklippen near Mestersvig in Central East Greenland, and also at the Black Angel mine at Maarmorilik in the Ummanaq district. These are the mines that have had an impact on Greenland's history and on its mineral policies. There have been other mines operating, most of them around the turn of the century: Copper at Kobbermine Bugt and near Qaqortoq (Julianehåb), graphite at Amitsoq near Nanortalik and Sisimiut

(Holsteinsborg), and marble at Maarmorilik. Common to all of these was their small size, brief life and limited profitability.

In addition to the treatment of the four important mines the present chapter examines private investment in mineral exploration as well as publicly funded research related to mineral resources.

This chapter is designed to provide information on the extent and scope of mineral activity in Greenland, from the early cryolite activities to the present efforts to discover mineral deposits which can replace the Black Angel. The underlying purpose in collecting and reporting the information given in the following sections is to provide a background for the discussion in chapter 7 of mineral policies pursued in Greenland.

The connection between economic theory and the present chapter is tentative. For the discussion of mineral activities the principal area of interest is rent capture and rent capture methods. The examination of mineral exploration investment is primarily designed to put the analysis of recent policy changes into perspective. The level of investment can be seen as an indirect indicator of investor interest, but this indicator must be used with caution since there is no obvious standard against which to measure such interest.

The third part of this chapter concerns government investment in mineral research and data acquisition. The data presented in this part cannot say whether government should invest but indicates which minerals the Mineral Resources Administration has chosen to emphasize in the case of Greeenland.

The four sections on former mines in Greeland are quite variable in terms of length and scope. The cases of Ivittuut and Marmorilik are discussed extensively while the the two other mines are accorded much less attention. The reasons are two-fold. One is that the Ivittuut and Marmililik mines were large compared to the other two, and therefore better documented. This is particularly true in the Ivittuut case, although the section on this mine relies on one

reference only. The Marmorilik mine is also extensively documented but some aspects of this case are deferred to chapter 9.

MINING HISTORY IN GREENLAND

The four important mines in Greenland have, in some ways, had considerable impact on the Greenland economy and on Greenland society. The impact ranges from employment of local factors of production and other inputs, over trade balance effects to the impact on Danish Government Revenues.

Cryolite at Ivittuut[39]

The cryolite deposit at Ivittuut in South West Greenland had been known for some time when, in 1850, it was discovered that soda and aluminium oxide (the latter known under the name of alum) could be produced from the mineral. A production of soda was established, and responsibility for mining was given to the Royal Greenland Trading Company in 1853.

The first cryolite company was founded in 1857, and its concession to mine the cryolite deposit was extended several times in the first few years of operation. In one of several restructurings in the late 1860s, the mining operation was separated from the processing operation. The Cryolite Mining Company began selling cryolite under long-term contract to the Pennsylvania Salt Manufacturing Company, and production increased steadily to around 10,000 tons annually in 1865. The workforce was around 100 in the summers, while a much smaller number (probably around 10-15) remained during the winter to maintain the site and the equipment.

In the last quarter of the 19th century cryolite production remained stable, despite diminishing importance of soda produced from the mineral. Instead, demand came from new uses of cryolite, as enamel, and as a flux for the smelting of aluminium in the Hall-Heroult

[39] This account is based on Niels Henrik Topp's exhaustive history of the cryolite industry (Topp 1990)

process. The processing operation in Copenhagen was organized under the Cryolite Company Øresund A/S, and this company was also responsible for the marketing and some of the processing (very little was actually done since the grade from the mine was often closer to 100% cryolite than to 90%). Øresund A/S had a world monopoly on the sale of natural cryolite, and potential competitors wishing to sell synthetic cryolite were met with strong price competition when Øresund A/S's market was entered.

Between 1903 and 1913, both Øresund A/S and the Cryolite Mining Company A/S earned large profits and this led to increased pressure for a greater government share of these. In the original concessions from the 1850s, the method of revenue collection had been a form of production sharing, whereby the government was entitled to 12 % of the cryolite shipped to Copenhagen. This cryolite was then re-purchased by the Cryolite Mining Company A/S, and the payment was then the tax. The share in production had been raised to 20 % in 1864. In 1914 a new concession was negotiated which changed the tax to a fixed payment per cubic meter, the amount depending on annual production. The years of the first world war were also very profitable for the two companies, and the period of strong demand continued after the war. During this period, the relations between the two companies became increasingly close, Øresund A/S becoming the only seller of cryolite outside the United States.

An attempt in 1924 by another Danish firm to replace Pennsalt as the seller on the US market drew attention to the very profitable cryolite industry. Negotiations over an amendment to the 1914 concession began, and were concluded in 1926. It was agreed that the royalty should be converted to a tax on mining company profits, the tax being one third of profits. In addition, a extra progressive tax (rising in increments of 5% for each half million profits, from 10% of profits above DKr 4 million to 35% of profits in excess of DKr 6.5 million) was imposed. At the same time, the mining company and Øresund A/S agreed to share the burden of the tax payments. The new tax regime meant that the government became more interested in the management of the cryolite industry and in the cut-off policies adopted at the mine.

The 1914 concession was to expire in 1939 and the 1926 amendment provided for negotiations on the future of the mine to start in 1934. Again, the government wanted a still larger share in the profits, and more direct control over the two companies. After protracted negotiations, the companies and the government reached an agreement under which the two companies were merged. In the new company the government owned 50% of the shares. In return the government would supply an open-ended mining concession, and the private shareholders would pay their share by transferring the production and mining facilities and equipment in Copenhagen and at Ivittuut to the new company. Instead of taxing the company, the state shares (A-shares) were to receive 60% of dividends as well as additional percentages (on a sliding scale) of dividends in excess of 6 million DKr. The new company was to be formed on January 1st, 1940.

The German occupation of Denmark on April 9th, 1940 cut transport links with Greenland. The Øresund plant in Copenhagen could process remaining stocks and reprocess various waste materials, but after the first war-years, the plant was idle. In Greenland, however, mining was expanded to supply demand created by the war. The cryolite was marketed by Pennsalt and Alcan.

After the war, cryolite markets were depressed for several years. The company was troubled by the recurring disagreement between government and private interests which arose as a result of unfortunate incentive effects of the dividend paymernt schedule in the 1935 concession. This was solved by agreement on a fixed split of dividends from 1950 onwards. In the postwar period, from 1950 to 1962, the remaining cryolite reserves were mined, and high-grade material, used to construct various dams and piers in the early years, was also processed and shipped to Copenhagen. Processing of material continued in Copenhagen until 1990, when low grades made further production uneconomic.

The cryolite company had initially hoped to discover new mineral deposits in Greenland and accumulated substantial financial reserves to enable development of discoveries.

These were, however, limited to the Mestersvig Lead-Zinc mine operated by Nordisk Mineselskab, in which the cryolite company was the largest shareholder. Other projects were investigated and abandoned, most notably a gigantic (see below) iron ore project at Isua in the bottom of the Godthåb Fjord.

During the late 1960s and 1970s, the hope of finding mineral deposits that would allow the company to stay in the mining business receded, and the accumulated financial reserves had to be put to better use. The company diversified into other businesses, and when processing of various waste dumps was ending, the company had moved far away from its original business. It was natural for the government to sell its shares in the company. This was done in November 1985, and the net revenue of DKr 731,250,000 was transferred to the state.

Despite the withdrawal of the cryolite company from Greenland, this does not mean that the cryolite resource is exhausted. Shortly after the privatization, the government was criticized for its decision to privatize the company based on the fact that some cryolite resource remained at Ivittuut[40] (Grønning-Nielsen 1987). Both the pit and various waste dumps and land-fill material contain considerable quantities of low-grade cryolite. A junior mining company is currently trying to bring these reserves into production before a newly discovered cryolite deposit in Brazil begins production (Jens Gothenborg, personal communication, 1992).

Coal-mining at Qutdlissat

The Cretaceous age sedimentary rocks in central West Greenland contain significant coal seams. These have been worked in various locations on the island of Disko and on the adjacent Nuussuaq peninsula. The first mining activities are not well known, but are assumed to have

[40] The political and technical argument was based on drill-results which indicated the presence of additional low-grade cryolite material at the bottom of the pit. The inquiry revealed that the distinction between "ore" and "mineralized material" had not been understood by many of the involved individuals, both politicians and inside the Mineral Resources Administration-Geological Survey of Greenland system.

been the work of European whalers (Schiener 1976) and sporadic mining activities for local use took place at a handful of locations.

More organized mining began in 1920 under the auspices of the Royal Greenland Trade Company. Mechanization was first introduced in 1929, but it was not until 1954 production was expanded above the level of previous years (when it averaged around 4,000 tons annually). The production reached a peak in 1963, when around 39,500 tons were produced. Since then, the production fell steadily and was discontinued in 1972 (Schiener 1976), and all the residents of the mining town were forced to resettle elsewhere in Greenland. At no time had the production yielded any profits.

The economic results from this mine were not encouraging. The Danish National Accounts show that for 1959-60, early in the production expansion phase, the loss was DKr1.49 million. This rose to DKr3.02 million in 1964-65 and was DKr4.03 million in 1970-71.

The Blyklippen lead-zinc mine at Mestersvig

The lead bearing veins at Mestersvig in central East Greenland were discovered in 1948 by members of a geological expedition led by Lauge Koch, and continued in 1950 and 1951. A prospecting company with Kryolitselskabet Øresund, other Danish companies and the Danish government as shareholders (the latter taking a 27.5% shareholding in the venture) was formed in 1952.

Nordisk Mineselskab A/S decided to develop the deposit for production. Mining began in 1956 and continued until 1962. A total of 545,600 tons of ore was mined, with an average grade of 9.3% Pb and 9.9% Zn (Harpøth and others 1986). Employment at the mine averaged between 85 and 90 men. There is no indication that any local labour was used[41].

After the end of mining in 1962 the company was engaged in various exploration ventures, mainly in central East Greenland. The most notable result of these projects was the discovery of the Malmbjerget molybdenum deposit in Werner Bjerge, a short distance SW from

[41] Nordisk Mineselskab A/S Annual reports 1955-63.

Mestersvig. This porphyry type deposit, which is estimated to contain 150 million tons of ore with an average grade of 0.23% MoS_2 and 0.02% WO_3, was investigated in several stages in the 1960s in a joint venture with AMAX Inc., and re-evaluated in 1978-81, following the development of new exploration models for this type of deposit (Harpøth and others 1986). During this period, the company was also involved in EC sponsored research into tungsten and molybdenum prospects in the area.

During the 1970s, Nordisk Mineselskab became involved in on-shore oil exploration in a joint venture with Atlantic Richfield Company. This project was located in Jameson Land, the large peninsula between Mestersvig and Scoresbysund. Extensive seismic surveys and geological mapping was carried out but the project was finally abandoned in 1991. Shortly afterwards, the assets of Nordisk Mineselskab were turned over to Nunaoil, the joint Greenlandic-Danish State oil and mineral exploration company. Over the years of its existence, no dividends were ever paid to the shareholders, and the princely sum of DKr 120,000 accrued to the Danish state as royalties and taxes.

The Black Angel Lead-Zinc mine at Maarmorilik

The name "Black Angel" refers to an angel-shaped outcrop of dark pelitic schist in an otherwise light-coloured cliff-face opposite the small settlement of Maarmorilik in the Ummanaq district of central West Greenland. The ore deposit of the same name outcrops above the angel figure in the same cliff, but sulphide lenses extends Eastwards for about 2 km and outlying lenses have been found in the vicinity, including one beneath the inland ice (Thomassen 1991).

The deposit was first discovered in the 1930s, when marble quarrying began at Maarmorilik (hence the name), but commercial testing and drilling only commenced in the 1960s, when a consortium led by Cominco Ltd. of Vancouver became interested. Development of the ore body for production began in 1971, with Cominco being the main owner of the operating company Greenex A/S.

When mining began in 1973 the total reserves were 4.1 million tons with an average grade of 15% Zn and 5% Pb. Over the life of the mine, from 1973 to 1990, these reserves were more than doubled, to 13.6 million tons with an average grade of 12.3% Zn and 4.0% Pb. Of this, 83% was recovered at the mining stage, the remainder being tied up in pillars (Thomassen 1991).

The interesting aspect of this mine is not only the considerable revenues that it generated for the governments of Denmark and Greenland, but also the terms under which the mine operated. These were set out in the concession agreement between the Ministry for Greenland and Greenex, the operating company, and are in effect a detailed statement of mineral policy which served to define the rather loosely formulated Mining Law for Greenland from 1965 (See chapter 7 for a discussion). This complex set of rules was further extended when, in 1986, Greenex was taken over by the Swedish mining company Boliden AB, at a time when Comico wished to close and abandon the mine. Further regulations covering the terms for site rehabilitation were added at this time. The local impact of the mine is described in chapter 9, while government revenues are noted below.

MINERAL INVESTMENT IN GREENLAND

A factor of major importance in assessing the outlook for mineral production in Greenland is the size of investments in exploration, the extent of exploration efforts as well as the investments in development and exploitation.

Private exploration investment

It is not possible to determine the exact expenditure on exploration before 1986. A compilation of reported expenditures has been prepared by the Mineral Resources Administration for Greenland which indicates a significant increase in spending (even if the sums are quoted in current prices), as illustrated in figure 3.1. It is important to note that the limited statistical

data means that the curves for exploration investment are affected by a few large projects. For 1989-1991, this was the case when the gold-PGM prospects at Skaergaard and Kap Edvard Holm in the Kangerdlugssuaq area on the East coast were being investigated.

Prior to 1986 no aggregate statistics are available, but it can be noted that the two major mines invested significant sums in on-site exploration for additional reserves at Maarmorilik and at Ivittuut, as well as in exploration in other parts of Greenland. All of these efforts were unsuccessful. The major projects included the investigation of the Malmbjerget deposit described above (in two phases which closely reflected the evolution of the geological understanding of this type of deposit), the Fiskenæsset chromite deposit, and the Isua iron-ore deposit. In terms of size and scope, the Isua project was probably the most interesting, with reserves conservatively estimated at 2 billion tons grading 38% iron. The project was abandoned in 1976 due to the depressed steel market at the time.

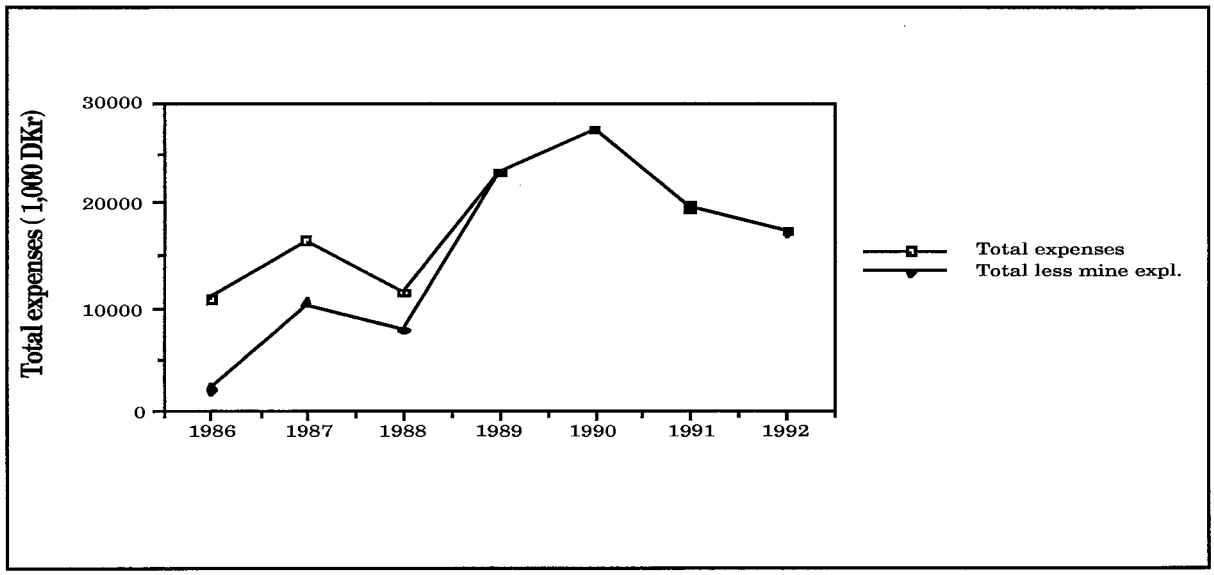

Figure 6.1. Metallic mineral exploration spending in Greenland 1986-91 (from unpublished MRA data) in current prices.

Oil and natural gas have also received considerable attention. In the mid-1970s a licensing round for areas off-shore West Greenland led to extensive but unsuccessful seismic work and five wells. The period 1986-91 has seen three major efforts, and one smaller project under-

taken. The first of these was the Jameson Land project, an ambitious joint venture between Atlantic Richfield Company (ARCO), Arktisk Minekompagni A/S (a subsidiary of Nordisk Mineselskab A/S) and Nunaoil A/S (the latter two on a carried interest basis), which later came to include AGIP, the Italian oil company. Soon after this project was initiated, the terms (mainly the work requirements) were re-negotiated, and the total amount of required work was sharply reduced (Mineral Resources Administration for Greenland 1987). The exploration continued until 1989, when the operating company, ARCO Greenland A/S, announced that it would withdraw from the exploration concession due to poor geological prospects for discoveries (Mineral Resources Administration for Greenland 1990).

Jameson Land is still considered an area of potential interest to the international oil companies, due to the extensive quantity of geological and engineering-related information assembled (and preserved by GGU), and partly due to the existing ground facilities in the area (the Constabel Pynt air-strip and supply base). To obtain these disappointing results, ARCO and AGIP spent a sum roughly estimated at 200 million $US.

During 1987-89, a group of six oil companies (Exxon, Shell, BP, Statoil, Texaco and Japan National Oil Corp.) and Nunaoil A/S set up a joint seismic exploration program. Each partner holds a $14^2/_7$% interest in the KANUMAS project (Kalaallit Nunaat Marine Seismic Program), but the interest of Nunaoil is carried by the other partners. This project involves extensive seismic surveys in the ice-filled waters off NE and NW Greenland. Total committed spending on this project is 17.4 million US$

Government administration and exploration projects

Government sponsored mineral related activities in relation to Greenland are carried out by the Mineral Resources Administration and by the two agencies controlled by the MRA, the geological survey (GGU) and the environmental research agency (GM).

Of these the MRA is responsible for administration, and also acts as secretariat for the "joint committee". The annual MRA budget in 1991 was DKr 7.8 million, of which 4.2

million (54%) went to salaries, and the remainder to goods and services[42] (Ministry of Finance 1993). The latter sum (DKr3.6 million) also includes the expenses of the Joint Committee on Mineral Resources. This body meets twice annually, alternating between Greenland and Denmark.

Systematic geological mapping in Greenland has taken place since Lauge Koch in 1928 began mapping the East coast of Greenland North of Mestersvig, in what was to be one of the most remarkable efforts in the history of geological science. The project proceeded until 1940 and was resumed in 1946-58 to complete a geological map (in 1:250,000) of the entire Caledonian orogen in Greenland (Minelovskommissionen 1963).

In the rest of Greenland a geological survey independent of Koch was established in 1946 in cooperation with University of Copenhagen. Initially the survey's work was based on a pure research foundation (Minelovskommissionen 1963), but cooperation with the Danish Atomic Energy Commission from 1957 onwards introduced a strong element of prospecting into the survey's work.

The Mining Law Commission established in 1963 was asked to examine the future of the GGU. It firmly emphasized the survey's role in basic research while rejecting the need for a state prospecting organization[43]. The legislation defining the nature and tasks of the GGU was enacted in 1965 along with the first Mining Law.

Despite the optimism concerning private exploration investment expressed by the Mining Law Commission, a large share of mineral exploration activities over the years have nevertheless been funded and operated by the Geological Survey of Greenland. Financial support has been

[42] Using budgets of latter years is misleading because of an "over-budgeting" tradition whereby the MRA appears to be allocated significantly more resources in the annual government budgets than what is actually needed and what ends up being used.

[43] The rationale in this rejection was that such an organization was unnecessary once the Mining Law proposed by the commission had been enacted.

derived from GGU's operating budget, and from external sources such as energy research grants and special appropriations by the Mineral Resources Administration for Greenland.

It is difficult to separate individual projects operated by GGU from the general accounts. Special appropriations in the petroleum field have included DKr 12.4 million in 1990, 5.5 million in 1991 and 13.2 million in 1992. These are reflected in the estimated division of spending on research shown in table 6.1.

The major source of funds for these petroleum projects has been accumulated savings in the MRA's account. These funds were originally paid as concession fees by the partners in the Jameson Land petroleum concession - and were seemingly earmarked for further petroleum activities. Funds from this savings account have also been used to finance the Danish government's share of an expansion of the equity capital of Nunaoil A/S, the joint Danish-Greenlandic petroleum and mining exploration firm.

TABLE 6.1. GGU EXPENDITURES 1988-94 (MILLIONS DKR)

	1988	1989[a]	1990	1991[a]	1992	1993	1994[c]
Research total	21,700		33,600		36,659	20,300	20,900
Geological mapping	9,300		7,500		6,910	7,200	7,200
Mineral activities	4,400		5,600		10,531	6,800	6,600
Petroleum activities	4,600		18,200	b	17,275	4,700	5,950
Glaciology	3,400		2,300		1.94	1,600	1,150
Total budget	43,200	42,200	54,900	44,400	53,563	37,000	36,700

Notes:
a. No data are available for the years 1989 and 1991;
b. For 1991, petroleum expenses were at least 5.5 million;
c. Expected budget.
Source: Finance Bill, 1993 (Government of Denmark)

The Greenland Environmental Research Agency was created in 1988 when the environmental service was separated from the Greenland Fisheries Research Agency. With an allocation of 12-15 full time staff and a budget of around 7.5 million DKr this agency is primarily

responsible for environmental matters related to mineral activities. Environmental policy in Greenland is otherwise a Home Rule responsibility.

Government Revenues

As noted above, the only two operations to earn any significant revenues for the Danish and Greenland governments have been the Ivittuut cryolite mine and the Black Angel lead-zinc operation.

The data presented by Topp (1990) allows a complete time series of revenues to be constructed. By using a consumer price index for the period from 1870 to 1985 (Bjerke and Ussing 1958; OECD 1955-; OECD 1962), the annual revenues can be converted to 1985 terms. Adding this to the revenues from privatization of the Danish government's shares in the cryolite company in 1985 (DKr 731.3 million) gives the total revenues from this mine, expressed in 1985 terms: DKr 3.86 billion.

A similar calculation has not been carried out on the more recent data on revenues from the Black Angel mine. The types of taxation used for this mine, and their revenues are shown in table 6.2.

TABLE 6.2. TYPES OF TAXES IN THE BLACK ANGEL CONCESSION AND TOTAL REVENUES (CURRENT 1,000 DKR)

Type of taxation	Total revenue
Area leasing charge	15,681
Dividend tax[a]	128,681
Concession tax	395,296
Personal income tax from employees[b]	248,565
Total revenue	788,223

Notes:
a. Not payable for shareholders not resident in Denmark or Greenland.
b. Not normally counted as mineral revenue (see also tables 9.5 and 9.6).
Source: (Mineral Resources Administration for Greenland 1991).

The Joint petroleum and mineral exploration company Nunaoil A/S

When petroleum exploration in Jameson Land was begun in 1985 the concession specified that a state company should participate in the project as part of the economic terms. The purpose

was to "secure increased insight into, and influence over activities.....and it is also an important tool for obtaining government revenues from activities"[44] (Mineral Resources Administration for Greenland 1984).

A limited company was formed in January 1985 under the name of Nunaoil A/S. The initial paid equity was DKr 25 million, ownership of which was divided equally between the Greenland Home Rule Authority and the Danish Minister of Energy. The size of the capital was such that "....the company's expenditures in the exploration phase can be covered *on the most part* by returns from investment of the capital, such that gradual consumption of the capital is avoided"[45] (Mineral Resources Administration for Greenland 1984).

Initially the company was advised by, and partially operated under a management contract by a subsidiary of the Danish National Oil Company (DONG). The legislation authorizing the company was enacted in November 1984 by the legislative assemblies in Greenland and Denmark (Mineral Resources Administration for Greenland 1985). During 1985 and 1986 it was further discussed whether the company should also participate in mining projects. By March 1987 the legislative amendment allowing this expansion of Nunaoil's sphere of activity had been enacted (Mineral Resources Administration for Greenland 1987).

The activities of Nunaoil were now determined by the option clauses inserted into every new exploration concession issued in Greenland (see chapter 7). To support the company's new activities the two shareholders agreed that the equity could be expanded to a maximum of DKr 50 million. By 1989 this expansion had been completed (Mineral Resources Administration for Greenland 1990).

When the option clause policy was abolished in 1991, the role of the company was reconsidered (Mineral Resources Administration for Greenland 1990). Based on the fact that Nunaoil had accumulated considerable exploration experience and an international network of contacts, a revised role was defined. For mining projects this involved taking on the functions

[44] Author's translation.

[45] Author's translation, italics added.

of a junior mining company, including both project initiation and continuation of more advanced projects in partnership with private investors. For petroleum, where the option policy for state participation remains, the company will have a role both before and after licensing rounds. Before such rounds this would involve information activities, organizing consortia and interpretation of seismic data. After licensing, participation in the work of the consortium would be the main activity. Nunaoil's board of directors agreed to these proposals but noted that expansion of mining-oriented activities would require additional capital. As a result, the shareholders agreed to supply a further 12.5 million DKr each.

The current status of the company is that the nominal equity of DKr 75 million has been reduced somewhat by accumulated losses (which exceed the return from investment of the capital reserves of the company). The major activity of the company is now mineral exploration. The only petroleum activity is the KANUMAS project where Nunaoil is operator but is carried by the other partners. In mineral exploration Nunaoil currently holds 5 exploration permits and is a partner in two joint ventures (Mineral Resources Administration for Greenland 1993). Nunaoil has always operated at a loss. During the past 3 years, this has grown from DKr 1.9 million in 1990 to DKr 3.4 million in 1991 and to DKr 6.3 million in 1992. However, the company has managed to attract considerable external investment in the process. The KANUMAS project has seen a total of DKr 85.8 million spent, while somewhere between 5 and 10 million DKr has been attracted for metallic mineral exploration (Nunaoil Annual reports 1991 and 1992; John Pedersen, pers. communication, 1993).

In a very recent development Nunaoil has received DKr 30 million for off-shore seismic equipment. The investment is financed by the Danish government as part of the 1995 unrequited transfers to Greenland. Concurrent with this development, the legislation regulating Nunaoil A/S has been modified such that the company can operate outside Greenland (Mineral Resources Administration 1993b). This investment is partly counterbalanced by the decision by the Home Rule Authority to invest DKr 25 million in

airborne geophysical data-acquisition specifically targeted on on-shore metallic minerals (Mineral Resources Administration 1993c)

CONCLUDING REMARKS - THE IMPORTANCE OF EXPLORATION

The past history of mining in Greenland indicates that it is not a totally foreign activity, but one which have in the past given considerable benefits, mostly revenue to the Danish treasury, but also significant employment of Greenlanders at Maarmorilik, and a small share of the revenues from the mine to the Greenlandic treasury. It is therefore not an unwarranted optimism driving the desire for more mineral investment.

The essential building block for future mineral development is present investment in mineral exploration. The data presented in figure 7.1. show these to be in the range DKr 20-30 million annually, corresponding to roughly C$4-5 million. Unfortunately, this is a modest sum by several measures.

The work by Dogget and Mackenzie (1993) on Canadian data for the period 1943-88 indicate that the average cost of discovering an economic base metal deposit in Canada is C$ 65 million, while it is C$ 71 million for economic[46] gold deposits, measured in constant 1990 terms. These costs may not be directly comparable to Greenlandic conditions because Greenland has seen much less exploration than Canada over time. Nevertheless, the annual exploration expenses in Greenland have, in recent years, been one tenth of the average discovery cost for a base metal deposit in Canada (Dogget and Mackenzie 1993). At this rate it would take 10 years to discover one economic deposit.

The most recent (from 1991) data on worldwide exploration budgets indicate that companies with annual exploration budgets of at least US$ 1 million, expected to spend a to-

[46] Economic is defined by Dogget and Mackenzie as deposits with revenues of at least C$20 million and a realized rate of return of 8%.

tal of US$ 1.845 billion in that year. Compared to this, investments in Greenland are very modest in size.

The measures against which the Greenlandic investment record has been judged must, however, be taken with some reservations. The budgeted exploration in any year does not give an accurate impressions of the levels of investment. The work by Eggert (1987) suggests that exploration investment may fluctuate considerably, depending on events both internal and external to the industry. The factors controlling these episodes of high (and low) exploration investment include (expected) rising prices and demand, new technologies and new geological models (Eggert 1987). To this one may add new discoveries (although they are a category of new geological models), and government subsidy policies. The exploration fever currently gripping the Northwest Territories of Canada (see any recent issue of the Northern Miner Newspaper) may be a clear example of the former, while the extraordinarily high levels of exploration for gold in Canada in 1985-88 was partly the result of a heavy subsidy given through the tax system (the so-called flow-through financing).

A country wishing to attract investment must be aware of these episodes and must realize that in most cases they are outside any one country's control, the exception being subsidies. Furthermore, the lags involved from the initiation of exploration to the arrival of government revenues mean that it is rarely possible to base mineral policy on adjustments to episodes or cycles in the mineral supply process. Similarly, it is important also to remember the correlation noted by Eggert (1992), between the high share of exploration investment placed in Australia, Canada and the United States, and the high levels of publicly funded research into the mineral potential of these countries.

An issue of some concern is the recent expansion of petroleum-related activities. These have generally received a disproportionate amount of attention relative to metallic minerals. It can be argued that, given the long but unknown time which will elapse before off-shore

petroleum under extreme Arctic conditions brought into production, investment of public funds should favour on-shore metallic minerals.

The decision to expand the area where Nunaoil A/S can operate to include areas outside Greenland also raises a number of issues related to the activities and management of state-owned and subsidized enterprises. Space and time precludes further treatment of these problems here.

7

MINERAL POLICIES IN GREENLAND

The five major events related to mineral policy in Greenland are the trade regulations of 1781, which regulated the activities of the Royal Greenland Trading Company, the Royal Proclamation on minerals of 1935, and the Mineral Laws of 1965, 1978, and 1991. The present chapter describes these events, their implications for mineral operations, and presents an analysis of the content and adequacy of the latest regulatory effort. This is based on the framework for analysis established in chapters 4 and 5.

REGULATORY VACUUM BEFORE 1965

Mining operations in Greenland, other than occasional primitive uses of surface resources, were initiated in 1856, when the quarrying of cryolite in Ivittuut began. This operation, and a number of other small mines operating at the turn of the century, were all based on individual permits issued by the Danish Minister of the Interior under the 1781 regulations for the Royal Greenland Trading Company. However, during the period from the 1850s to 1965, a number of policy changes occurred, which had important consequences for the cryolite mine, and for

the future course of regulation. This section examines the mineral policy of an era where the state was not constrained by any specific mineral legislation. The Royal Proclamation of 1935 is not discussed since it had no direct impact on policy.

The early mines

The very early regulation of mining activity in the Kingdom of Denmark (which once included most of Norway, Sweden, Iceland, and Greenland) vested mining rights in the Crown, as distinct from the free-access which had existed in medieval times. During the 15th and 16th centuries, mining rights reverted to the crown. This process was gradual and probably reflected improved efficiency in mining, as well as a rent capture policy (Harhoff 1985). In Norway, where mining was concentrated, the Crown released its control over all minerals except gold and silver in 1643. The latter minerals were released in 1783 (Harhoff 1985). The result was free access to mineral exploration, and a system of property rights similar to the mineral tenure systems of many common-law countries. The concept of "free miners", which was part of the Danish Crown's opening of access, can also be traced, both forward to this day, and backward to a tradition in which sovereigns had to allow free access in order to attract the rare, skilled miners of the day (Kuehne and Trelease 1984). In Greenland, however, the principle of free access never applied. Under the regulations for the Royal Greenland Trading Company issued in 1781, trade in the area was reserved to a monopoly which was financed by the Crown. According to the regulations governing the operation of this monopoly, minerals were reserved for the trading company (Harhoff 1985).

Government equity participation

The relationship between the cryolite company(-ies) and the government, reflects the drastic changes which a successful mining project undergoes, as it moves from the initial high-risk

phase to a high profit phase[48]. As cryolite profits grew to "windfall" proportions, demands for a larger government share of these profits recurred every time the mining concession was renewed. Eventually, the taxation approach was changed from an additional profit tax system to a joint venture approach, where the government owned half the cryolite company.

The model with state equity participation was also used in the two cases where important mineral concessions were issued before 1965, i.e. for the lead-zinc mine at Mestersvig, and for the exploration of the Malmbjerget Mo-W porphyry deposit. In both cases, special legislation was used to set up the operating companies, and the state's share of equity was fixed at 27.5%, and 50%, respectively

THE FIRST MINERAL LAW

The mineral activities in Greenland after the second world war, most notably those in central East Greenland, indicated that more comprehensive regulation of mineral activities was needed. This resulted in the appointment, in 1960, of a commission to examine how a Mineral Law should be designed. The commission published its report, which included a draft Mineral Law, in 1963. It was not until 1965, however, that a Mineral Law was enacted by the Danish Parliament. This section examines the report and the final law text.

Analysis of the Mineral Law commission report, 1963

In its brief, the Mineral Law commission was directed to examine a range of issues related to mineral activities in Greenland. These included the general principles to be included in a Greenland Mineral Law, the future organization of publicly financed geological mapping and research, whether Greenland should be opened for [private] exploration access, how the local

[48] The high profits in this case were partially the result of the unique monopoly on natural cryolite described in chapter 6. Incidentally, the complete records of the cryolite company have been preserved and may be a very rare record of the actions and strategies of a natural resource monopolist.

population could be involved in mineral activities, whether standard terms for concessions should be drawn up, and how educational, social and health concerns could be provided for in relation to mineral activities (Minelovskommissionen 1963).

The reasons for setting up the commission were twofold. The first was that minerals in Greenland were in principle subject to the legislation covering the Danish sub-surface, while conditions in Greenland diferred significantly from those in Denmark. The second reason was that the late 1950s and early 1960s saw considerable mineral activity in Greenland which indicated the need for regulation.

The report first considered the question of mineral tenure, and distinguished between full title at the outset of exploration, and separate title for the exploration and production phases. The first option was rejected for two reasons. First, it was argued that the exact (economic) terms for a concession could not be determined without knowledge of future profits. Second, granting full tenure without specification of economic terms assumed that taxation of mineral profits could be handled by ordinary tax regulations.

To the extent that tax regulations did not exist in Greenland at the time and were unlikely in the foreseeable future, the second argument was valid, but only until a regulatory structure for taxing personal and corporate income was implemented. The first argument, on the other hand, was based on a limited understanding of the mineral industry and mining firms. It did not recognize that a range of uncertainties influence the size of future profits: The absolute size of the orebody depends on the cut-off grade applied, and this in turn depends on market prices for the commodity (-ies) mined, on production cost, and on the discovery of additional ore reserves.

In practical terms the report proposed that three phases of exploration activity should be distinguished: Prospecting, covering large areas in a preliminary fashion; Exploration, which focuses on specific areas; Production, which is closely tied to small areas. For prospecting, limitation in area size or work requirements were not considered necessary, since a permit to

prospect did not give any rights (other than access to operate in Greenland) to the holder. An exploration concession, on the other hand, would provide the holder with exclusive access, and therefore some form of work requirement was considered necessary.

The remaining proposals with respect to the design of mineral rights were unremarkable, covering the length of each type of permit (prospecting: 5 years; exploration: 8 years, or 12 years in North and East Greenland; production: 50 years), reporting of acquired information and access for scientific personnel to all sites either for inspection purposes or for unrelated scientific work.

Despite being directed to find ways to involve the local population in mineral activities, the commission's proposal was insignificant and superficial. Rewards were to be offered for information which led to the discovery of a mineral deposit.

The detailed examination of possible financial terms led the commission to reject what was described as the "Canadian model" of mining regulation (the commission report shows little evidence of a detailed analysis of either Canadian or US mining regulations). It was further repeated, that fixing economic terms for mining is difficult without detailed information in each case. Given the fact that high risk was involved, and that some element of quasi-rent is present as a result of the special knowledge accumulated in mining firms, the report proposed a financial structure very similar to that described from the cryolite concession of 1935.

In the version proposed by the commission the State was to have a 50% equity share in all mines developed for production, but was only to receive dividends when the other partner's capital investment (including related exploration costs) has been recovered along with a suitable rate of return. The proposed rent capture mechanism was essentially comparable to a 50% "Resource Rent Tax" (see chapter 4), with the government partnership formalized through equity ownership.

The final Mineral Law text

Since the 1965 Mineral Law was to regulate mineral activity until 1991, a brief summary is necessary. This also gives an impression of how the civil servants drafting the Mining Law thought about mining and mineral policy in Greenland.

The Mineral Law consisted of 28 sections divided into five chapters. The first defined general principles, including free access for the local population to use surface materials. The second chapter (sections 4-7) concerned prospecting, or "preliminary investigation permits", and defined activities which required separate permission (blasting, drilling and underground work). Preliminary investigation permissions, as well as exploration concessions could require the holder to guarantee financially any costs the State might incur in relation to the prospecting activities, including rescue operations (section 6). Permitees also had to report their results to the authorities within 6 months of the expiry of the permit (section 7) .

Chapter three concerned the terms for exploration concessions. These could be issued to applicants possessing suitable skills and financial ability, and required annual reporting of activities. The concession allowed the holder to use land in the concession area for exploration purposes, but also that land not so used remained open for surface access. In contrast to preliminary investigation permits, the exploration concession involved a duty to carry out exploration work, as indicated in the plans submitted to the authorities (section 14[1]). If no exploration activity was recorded for a period of 3 years, or if *any* of the terms in the Mineral Law were not complied with, the concession would expire automatically (section 14[2]).

The fourth chapter, on production, set out that the applicant had to be a corporation registered in Denmark, that plans for production had to be submitted and approved, that concessions to explore *generally* gave the holder a preferential status to obtain a mining concession[49] (section 15), and specified the content of the concession. This included the term (50 years), that some minerals could be excluded from the concession, that annual reporting was required,

[49] In cases where the mining concession was given to others, section 16 described how the initial holders of the exploration concession were to be compensated.

that activities were subject to inspection, that employment of local labour could be required, and that the concession lapsed if production stopped for more than two years, or if terms and conditions laid down in the Mineral Law, or in the concession were not complied with (section 22). With respect to taxation of mines, section 17 simply said that concessions had to secure the State's share in profits after the investment and a reasonable rate of return has been recovered. Alternatively, other forms of taxation could be applied. The final chapter gave the minister the power to regulate in areas of mine safety, worker safety and to define a number of administrative procedures.

More than anything else, the 1965 Mineral Law is a framework into which civil servants could fill all the necessary details by using the concession texts as the outlet for specific regulation. This practice is widely used in Danish legislation, although details are usually set out in regulations, rather than in individual concessions. The use of this approach is also a powerful indication of the rather narrow outlook on mineral activity which appears to have prevailed in the Ministry for Greenland at the time, and the structure of the Mineral Law seems designed to handle a very limited number of cases in a highly bureaucratic manner.

In terms of investor risk, three important features contributed to an overall perception that the 1965 Mineral Law was unable to provide a sufficiently low-risk investment environment.

1. The possibility that a production concession might not be given to those who held the exploration concession for an area where a deposit has been discovered. The clause actually specifies that this can happen only when "very special circumstances" made it "a reasonable course of action". The wording of the clause is not in itself extreme when read by anyone familiar with Danish legal tradition, and seems intended to provide an escape clause with which "undesirable" operators could be screened off. The clause was proposed by the Mineral Law commission, but the report (Minelovskommissionen 1963) gave no supporting argument, but noted that cases might occur where it is necessary to give the concession to someone other than the exploration concessionaire.

2. Economic terms of mining operations are not well defined in the Mineral Law. The problem is not that the need for capital recovery and a return on investment is not recognized, but rather that the terms are not precisely defined. As noted, the lack of clarity on this point is a consequence of the mistaken belief that economic terms can only be determined when the value of a deposit is well known.

3. The general possibility that a concession could be revoked if any condition in the Mineral Law, or in a concession, was not observed, was an added element of uncertainty.

The concession for the Black Angel deposit issued to the Cominco subsidiary Greenex A/S, in 1971, partially reflects the problem of insecure tenure and unknown economic terms. It took 4 years to negotiate and issue this concession (1967 to 1971) and during this time the exploration of the deposit proceeded under an exploration concession issued before the enactment of the Mineral Law. The Canadian investors specifically wanted a concession which combined the exploration and production phases in order to carry out a feasibility study of the deposit (E. Dragsted, cited in Bruun and Mortensen (1991)).

MINERAL LAW CHANGE AND HOME RULE

Greenland was granted extensive Home Rule with the enactment of the Greenland Home Rule Law in 1978. At the same time the Greenland Mineral Law was amended to reflect the changed management structure. In the area of natural resources, the negotiations which produced the Home Rule bill had to resolve two related issues: Who "owns" the non-renewable resources of Greenland ?, and how can a compromise on this issue be implemented in an administratively practical way ?

The ownership problem

In the 1965 Greenland Mineral Law, the first clause boldly states that "all minerals in Greenland belongs to the State". To many in Greenland this was an extremely offensive statement

(Foigel 1980), and it became one of the thorniest problems in the negotiations over the introduction of Home Rule. Greenland representatives felt that the population of Greenland were the true owners of the country's mineral resources by virtue of their "aboriginal rights", and further that they could claim sovereignty over natural resources as a "people" in the sense of the UN Covenant of Human Rights (Article 2). The Home Rule Commission based its work on the fundamental assumption that the power to legislate and the power to appropriate funds could not be separated (Hjemmestyrekommissionen 1978). In relation to non-renewable resources this involved a balance between two diametrically opposed interests. On the one hand, political independence from Denmark would require that Greenland could sustain itself financially, possibly in part through mineral revenues. On the other hand, as long as the "Unity of the Realm" remained, the Home Rule Authority would be constrained in its mineral policies, and Denmark would retain some control (Harhoff 1993). This led to the formulation of three main principles to govern mineral resource policy:

1. Greenland and Denmark should have equal rights when it comes to designing and implementing mineral policy, and in important specific matters. This *equality* principle reflects that mineral resources are of vital interest to both Greenland and the nation as a whole.

2. There should be established a *joint* decision-making power, vested in the national authorities and the Home Rule authorities, with respect to major decisions in the area of mineral resources, such that either party can oppose a proposed resolution (the *mutual right of veto*)

3. Practical *cooperation* was to be established between political institutions, and the administrative and technical agencies necessary for adequate administration of mineral resources, such that the parties had equal access to all information.

These principles were laid down in section 8 of the Home Rule Law which states that "the resident population of Greenland has fundamental rights to the natural resources of Greenland". The rest of the section specifies that regulation of mineral resources is to be by agreement be-

tween the Danish Government and the Landsstyre, and that any member of the Greenland Landsstyre (members of the Home Rule cabinet) may demand that the matter be laid before the Landsting (legislative assembly).

Division of powers in the administration of mineral resources

The three principles underpinning the regulation of mineral resources determine the allocation of powers and the administrative organization described in figure 7.1.

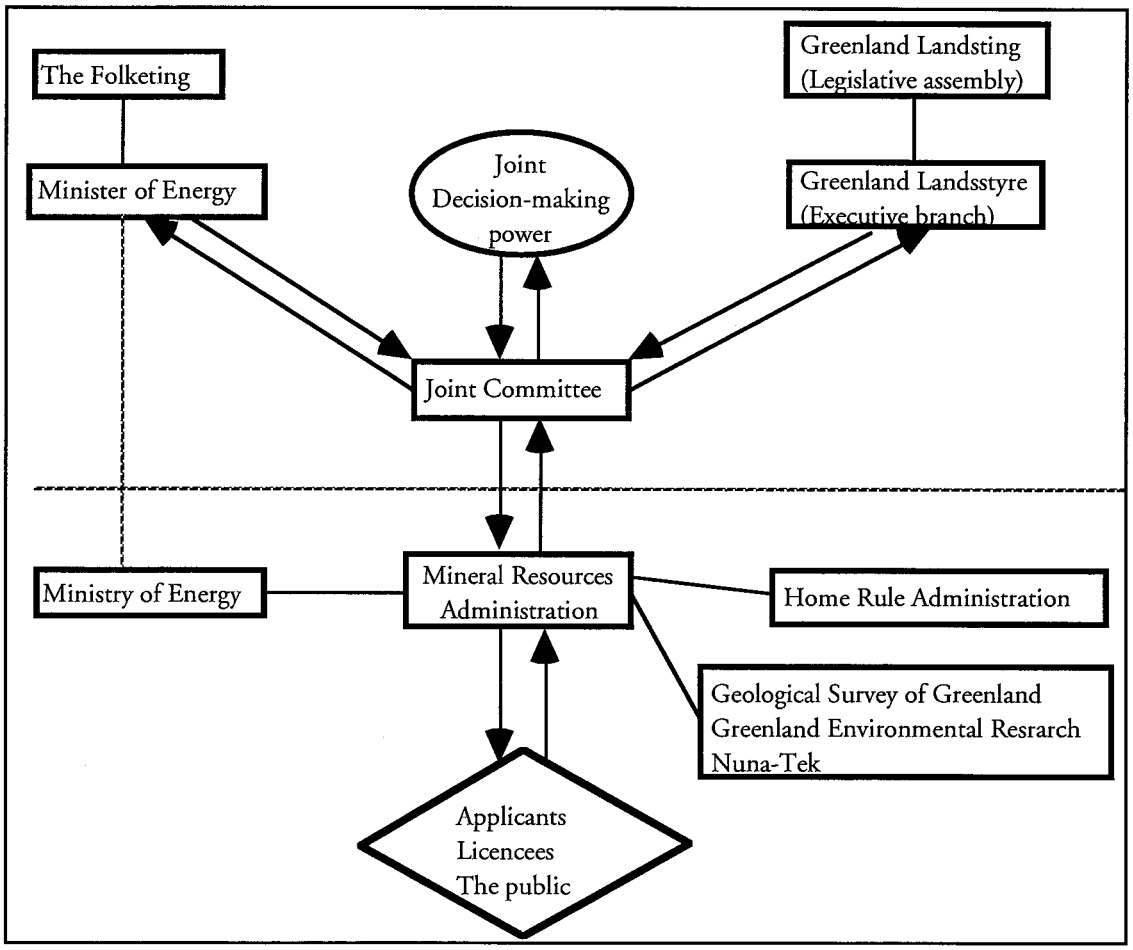

Figure 7.1. Organization of the "Joint decision-making power" in relation to mineral resources in Greenland (modified from Foigel (1980)).

The Minister (of Energy) has the *power* to issue permits (Mineral Law sections 6 and 7), provided an agreement on the matter has been reached with the Home Rule Administration[50] (Mineral Law section 3).

The Joint Committee can give recommendations to the two governments in cases where agreements between the two must be reached (Mineral Law section 4[1]), i.e. in matters relating to individual permits. The Committee can also advise the two governments on other issues related to mineral resources. In legal terms the recommendations from the committee are not binding (Harhoff 1993).

The Mineral Resources Administration for Greenland (MRA) is a department in the Ministry of Energy, and is directed by a chief and a deputy chief. The chief is appointed by agreement between the two governments (Mineral Law section 5[2]). The MRA has two tasks. One is the ordinary administration of mineral rights (Mineral Law section 5[1]), while the other is its role as secretariat for the Joint Committee (Mineral Law section 4[4]). It is important to note that the MRA is subject to the Minister's powers when carrying out its first task, whereas the power to instruct the MRA in its second role lies with the Joint Committee (Harhoff 1993)

As noted above, the mineral resources issue was one of the most difficult to resolve when Greenland was granted Home Rule in 1978. The compromise described above involved, however, an important argument used to justify the location of the MRA as a Ministerial department (initially in the then existing Ministry for Greenland). The argument turned on the question of who should have the power to issue permits and concessions: The Minister, the Home Rule Authority or the Joint Committee ?

The latter solution was unacceptable from the Danish point of view because releasing control of any territorial area would interfere with the principle of the "Unity of the Realm" which is laid down in the Danish constitution (Harhoff 1993). The logical consequence of the linkage of control over minerals to territorial control was that only the Government of Denmark could dispose of mineral rights. The Greenland side in the negotiations was opposed to

50 This is the Joint decision making power.

this argument as a matter of principle, but fear of an "information monopoly" also played a role. A counter-argument of a similar practical nature was that placing the MRA under the Ministry was necessary in order to have the required administrative capacity in a complicated area[51] (Harhoff 1993).

A further argument for placing the operations of the MRA under the Ministry for Greenland (later the Energy Ministry) was that these operations had to be subject to the government's parliamentary accountability (Hjemmestyrekommissionen 1978). Nevertheless, a number of institutions in Denmark operate outside this accountability. These include the central bank, the national radio and television network, and the national oil company (DONG), and these are frequently referred to as "independent public institutions". This implies that, if political consensus exists, then it is possible to create independent institutions (Harhoff 1993).

Options for government participation, and the creation of Nunaoil

The notion of state participation in mineral projects has existed at least since the 1935 cryolite concession was negotiated. In the 1980s it was introduced during the negotiations over the concession to explore and produce oil in Jameson Land in central East Greenland. The idea seems closely related to the developments in Danish policy towards the petroleum concessions in the North Sea, where state company involvement was heavily promoted during the late 1970s and early 1980s.

During the autumn of 1986 the policy of state participation was extended to include other minerals than oil and gas and from that time onwards all prospecting permits and exploration concessions contained an option clause allowing state participation. The extension was first proposed by the Mineral Resources Administration in order to deal with a deposit con-

[51] An additional argument for having the MRA as a ministerial department was that control over concessions was necessary for the DK to be able to comply with international treaties on energy supplies (Foigel 1980; Harhoff 1993).

taining uranium as a by-product (Mineral Resources Administration for Greenland 1986). Subsequently, the idea was extended to cover all non-petroleum minerals.

Initially, the option was vague on the extent of the participation, but from January 1988 the option clause became more focused. It consisted of two parts, first an option for the state to acquire up to 25% of any exploration stage project in return for payment of past exploration cost in proportion to the state's share (i.e. max. 25% of exploration cost). This option had to be exercised within 2 years of the original concession issue date. Secondly, the state had an option for an additional share of up to 25%, depending on the size of the first option (i.e. if the first option was for a 20% share, the second option could be no larger than an additional 20%). Whether this second option was to be carried by the private investor or not remained unclear since the question was to be settled as part of the negotiations over the economic terms of a production concession (Mineral Resources Administration for Greenland 1988)

Revenue sharing between Greenland and Denmark

The revenue-sharing section in the 1979 Mineral Law provided for negotiations over the sharing of revenues in excess of the Danish transfer payments to Greenland. However, in 1988, the Home Rule government succeeded in changing the distribution formula such that revenues less than 500 million DKr annually were divided equally between Greenland and Denmark, while sums in excess of the 500 million were to be distributed according to later agreement.

The fact that Greenland was to receive no benefits from mineral exploitation until mineral revenues matched current net unrequitted transfers meant that the Home Rule Authority had no incentive to welcome mineral projects (Lyck 1988). Indeed, it may further be argued that the Home Rule Authority had an incentive in delaying activities until a better sharing mechanism was in place.

MINING POLICY REFORM, 1991

Generally bleak prospects for the Greenland economy, the closure of the Black Angel mine in June 1990, and the end of petroleum exploration in Jameson Land prompted a reappraisal of mineral policies in the spring of 1990. The driving force behind this effort seems to have been the Greenland Home Rule Authority, as indicated by the official records for the Greenland Landsting. During 1988, several speakers mentioned the need to provide more attractive investment terms[52]. To this end a group of experts was directed to examine the possibilities of mineral policy reform. The group was specifically asked to consider the following issues (Mineral Resources Administration for Greenland 1990a):

1. The major components of a policy designed to generate significantly greater levels of mineral activity in both the short and the long term;
2. Description of the conditions necessitating the change of policy, including the closure of the Black Angel mine and the problems facing other industries in Greenland;
3. Analysis and design of specific measures which could promote the policy goals, including changes in the terms offered to investors;
4. Examination of the possibilities of coordinating efforts to promote mineral activity with efforts in other industries in Greenland;
5. Address the division of administrative tasks in relation to efforts to promote mineral and other activity.

The group of experts, which all came from inside the MRA-structure, from Nunaoil or from the Greenland Home Rule Authority, was established on April 18th, 1990, and delivered it's conclusions a little over one month later, on May 23rd, 1990.

Objectives

The report (Mineral Resources Administration for Greenland 1990b) defines two long-term goals:

52 Grønlands Landstings forhandlinger 1988, p. 713.

1. A significant increase in activities, both exploration and production;

2. That society benefits from mineral activity through industrial development, employment, education, tax revenue, infrastructure, technology transfer, and internationalization, while the disadvantages associated with such activities are minimized.

According to the report, these goals require that Greenland is able to attract investment and technology by offering internationally competitive terms, that the mineral sector is not isolated from the rest of the Greenland economy, that society retains *sufficient* control over events in the mineral sector, such that the development process is *managed* and occurs in a *defensible* manner with respect to environment, safety and resource issues[53], and that mineral activities are accepted and understood in Greenland as a necessary part of life.

The goals are further described in separate sections on "hard" (metallic) minerals and "hydrocarbons", respectively. The report outlines the main goals for metallic minerals in geological terms, and argues that, on average, 40-50 exploration projects will generate 2,000 anomalies, of which 1,000 will be examined more closely, producing 50 interesting targets which are then reduced to approximately 3 targets of economic interest. One of these is then likely to lead to production. If mining is to contribute to the Greenland economy, between two and four medium size mines need to be operating along with several smaller ones. The conclusion is that Greenland needs to attract much investment in "hard" mineral exploration. However, the investment needed to reach this goal is not estimated.

The report set out the general goals in the petroleum area as between two and four exploration wells and 10-15,000 km seismic lines annually, valued at 50-100 million US$. Ideally these goals should be pursued with as many companies active as possible. Since financial

53 Both the strategy report, previous legislation and the new Mineral Law note that exploitation of minerals must occur in a way which is defensible in terms of "resource issues" without ever being specific about what this means. This may refer to common-pool problems (Libecap and Wiggins 1985). However, the MRA has in the past imposed production limits on the Black Angel mine (Greenex 1990), see the discussion in chapter 9.

commitments of this size require that terms and conditions of future operations are known, the report recommends that projects and exploration areas in various stages of advancement are promoted by the Government clearly signaling where, how and on what terms blocks will be offered for bidding/application during the next 5-10 years.

Mineral tenure

The recommendations with respect to tenure and economic terms distinguish between minerals and petroleum situations. For minerals, the report recommends that the security of tenure is improved by giving the holder of an exploration concession or permit the right to develop any mineral deposit he may find. The chief obstacle to such a clause seems to have been the desire on the part of the politicians to retain some form of right to decide whether mining should occur. For petroleum, the existing type of title was to remain unchanged.

Economic terms for minerals

The question of economic terms preoccupied the experts at length, the main issues being taxation of mining firms and state participation in operations. Key issues identified were the effect of corporate taxes and dividend taxes, including possibilities for tax credits in mining companies home countries, tax jurisdiction, and tax-based incentives.

The discussion of state participation in projects (based on the option policy described above) cited the advantages (improved information and influence, participation in production, acquisition of knowledge inside Nunaoil A/S), and the disadvantages (high share, private investor loss of control, difficulties in obtaining financing and lopsided distribution of risk). The recommendation was that options in the exploration phase be removed, but that an option for state participation in production remains, albeit at a much lower level than the previous 25%. The main preoccupation in this context was how to keep terms competitive. The report did not, however, include any information on what other countries are doing in this respect (Mineral Resources Administration for Greenland 1990b).

Economic terms for petroleum production

In contrast to the administrative policy pursued for metallic minerals, concessions for petroleum exploration have always been combined exploration and production concessions. The report argues that terms change over time in response to changing conditions in the world petroleum industry, and that individual licensing rounds may well differ with respect to taxation, state participation and work requirements. As a result, there is not the same need for fixed terms as in the case for minerals. Nevertheless, real offerings require extensive seismic investigations which again require private (i.e. oil company) investment. This will not be forthcoming unless the main terms and conditions of offerings are clearly stated.

THE NEW POLICIES AND THEIR IMPLEMENTATION

As a direct result of the report described above, a new "Greenland Mineral Law" was drafted and enacted by the Danish Folketing in May 1991. The Law itself sets out a general framework of regulation, specifying the powers of the minister, the rights and duties of permit-holders and the administrative structure. As companions for the new Law, a document specifying "Principles and Procedures" as well as different sets of Standard Terms and conditions, covering petroleum exploration, mineral prospecting and mineral exploration/production, were drawn up. Here we first describe the principal features of the Mineral Law, and then the more detailed regulations.

The 1991 Greenland Mineral Law

The first chapter is similar to the 1979 law and regulates the administrative structure. The most important section is the third, specifying that all permits, whether they be for prospecting or exploration/production are issued according to agreement between the Danish and Greenland governments. Thus, in principle each and every project needs political approval.

The second chapter, on preliminary investigation permits, has an addition allowing the authorities to require various payments. Generally, more detailed regulation, some of which previously appeared in the corresponding chapter of the 1965 Mineral Law, is delegated to the minister.

Exploration and mining are covered by chapter 3. The first type of permit is a "preliminary investigation permit" which allows the holder to prospect but which does not give any exclusive right. Alternatively permits can be issued giving the holder the exclusive right to explore and mine. The remaining sections of chapter 3 allows the minister to charge fees and other payments, to require state participation[54], to require use of local labour and suppliers, and to specify that development plans must be approved. This chapter thus sets out the general principles and ministerial powers in all mineral resource questions.

The fourth and fifth chapters contain specific regulation of petroleum and minerals, respectively. With respect to petroleum, the term of each type of activity is defined (exploration can go on for a maximum of 16 years, while extensions for production purposes are for a term of 30 years). Otherwise, the main special provision for petroleum allows the minister wide powers to make companies with adjacent blocks covering the same reservoir cooperate.

The special provisions for metallic minerals also set out the length of concessions (exploration 16 years; production 30 years), and emphasize that the holder of an exploration permit has the right to obtain a mining concession. The final section in chapter 5 (section 16) specifies that the economic conditions for mineral production can only include taxes, royalties, rental fees and state participation to the extent that these were set out in the exploration permit.

The new Mineral Law has special provisions for the protection of environmental values, including one which allows the minister to require developers to post reclamation bonds.

54 This is the general rule. Section 16 then limits this power to situations where [options for] state participation have been specified in exploration permits, or where exemptions from taxation has been granted.

Abandonment plans must be provided when mine development is proposed, and developers must show that provision has been made for their implementation.

Chapter 9 of the Mineral Law describes the formula for sharing mineral revenues between Greenland and Denmark, which is unchanged from the 1988 revision of the Mineral Law, and defines the types of revenue subject to the sharing agreement. The sections in chapter 10 vests a range of powers in the minister, and defines the duty of the concessionaire to operate in an environmentally and operationally safe manner, such that exploitation takes place in a "sound" way with respect to resource use[55].

The minister can issue regulations in respect of these matters, and must approve any construction or changes in plans according to the terms set out in the concession. Inspection, reporting etc. is also subject to separate sections. The final chapter contains a number of miscellaneous provisions. Individual concessions must set out the extent of the concessionaires duties *after* the expiry of his concession. Danish laws of compensation apply, and concessionaires can be required to take out special insurance coverage. In cases where mining occurs without permission, where concessionaires fail to obtain proper permissions, disregard the terms of their concession, or fail to observe orders issued under the Law, the appropriate sanctions may be fines or jail sentences.

Principles, Procedures and Standard Terms

The new Greenland Mineral Law leaves many details to be regulated in each permit. The approach adopted by the Mineral Resources Administration is one of issuing a document specifying "Principles and Procedures"(Mineral Resources Administration for Greenland 1992d), accompanied by sets of "Standard Terms" for preliminary investigation permits, and exploration permits, respectively. Each license or permit consists of a page defining the area in question and that the terms are the Standard Terms for the type of permit in question.

55 As in the 1965 Mineral Law and later amendments the meaning of this is not elaborated.

The Principles and Procedures document describes in detail how applications should be made, how they are formally processed, how competing applications for exploration licenses are treated, and further a number of points also contained in the Standard Terms. The important rules in this document concern the administrative processing of applications. Figure 7.2. gives an impression of the process. It basically involves both an administrative and a political review, and then the Minister and the Home Rule Authority makes a decision and the Minister issues the permit. However, in practice the procedure can be much simpler. According to the rules of procedure of the Joint Committee applications can be processed by the Chairman and the two deputy chairmen of the Joint Committee, and their recommendation can then be endorsed at the next full meeting of the Committee (Mineral Resources Administration for Greenland 1992b).

The Standard Terms then provide the detailed rules for the mineral activity, including area definitions, term limits, charges and fees, activities of others in the area, work requirements and allowable expenses, approval of activities, inspection, abandonment of sites, reporting, use of local labour and suppliers, the transfer from exploration to production, transfer of permits, the forfeiture of permits, liability, dispute resolution, and remaining liabilities after the expiry of a permit.

For exploration permits the Principles and Procedures document (Mineral Resources Administration for Greenland 1992d) sets out the normal items: The term of the license, its extent, as well as inspection (applies only where major operations such as drilling or blasting, are undertaken), and work requirements. Holders of preliminary investigation permits are under no obligation to conduct work in order to keep their permit in good standing, and need not refund administration costs. The MRA can, however, require payment for the cost of site inspections.

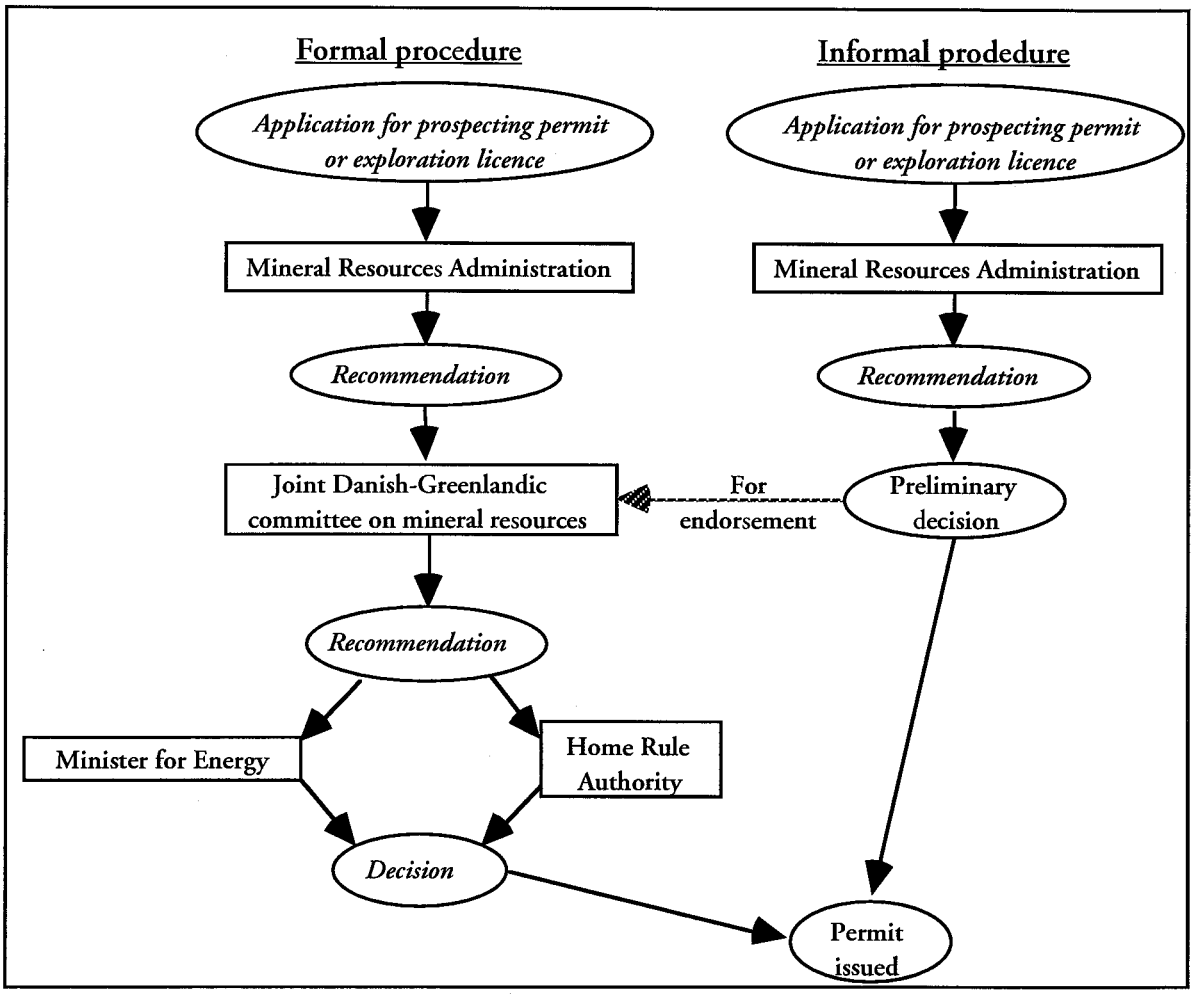

Figure 7.2. Administrative processing of applications

Work requirements for exploration permits are based on a combination of a fixed sum per license, and an additional amount depending on the size of the permit area, see table 7.1. Only those activities and types of expenditures defined in the Standard Terms for exploration licenses are allowed for the calculation of work[56]. Special provision is made for exploration in remote regions (North of 78°N in West Greenland and East of 44°W in East Greenland). In these areas, longer time is allowed for exploration, and less work is required to keep licenses in good standing.

56 To improve the attractiveness of Greenland, the calculation of allowable expenses has recently been modified such that total allowable expenditures can now be inflated by 50%. This applies to expenditures in 1993 and subsequent years (Mineral Resources Administration for Greenland 1993).

TABLE 7.1. ANNUAL WORK REQUIREMENTS (DKR)

Year	Work per license	Work per km^2
1-2	100,000	1,000
3-5	200,000	5,000
6-10	400,000	10,000
11-	To be agreed between applicant and the MRA	

Source: (Mineral Resources Administration for Greenland 1992d) Work requirements are to be inflated by the Danish Consumer Price Index

Following section 7 of the 1991 Mineral Law, the Minister for Energy can issue permits to explore and produce minerals. In "Principles and procedures" and the Standard Terms for exploration licenses, this is interpreted to mean that an exploration license can be converted to a production license, if certain conditions are fulfilled. The application to convert must be accompanied by the following documents:

1. A statement from the holder of the exploration permit stating that a deposit is commercially viable, and that the holder intends to exploit it;

2. A feasibility report on the deposit, upon which the statement (1) is based, and which can be used to obtain finance for development (i.e. a "bankable" feasibility report). The report must include a geological assessment of the deposit, as well as specification of the technical, economic and environmental parameters on which the statement (1) is based;

3. The licensee's proposal for the area to be covered by the mining lease.

Economic terms

The Standard Terms attached to exploration permits specify a number of fees applicable at various stages of the exploration process (table 7.2). The main form of taxation occurs, however, under the Greenland Income Tax Law. This was changed during 1991 as part of the mineral policy reform, and the tax regulations facing a mine operator are now fairly simple.

Firms domiciled in Greenland are fully liable for taxation in Greenland, whereas foreign firms carrying out mining operations are subject to limited tax liability.

TABLE 7.2. FEES FOR MINING RELATED PERMITS

Activity	Fee (1992 DKr, inflatable at Danish CPI)
Issue of preliminary investigation permit	15,000
Transfer of preliminary investigation permit	7,500
Issue of exploration permit	25,000
Annual fee, years 6-10	25,000
Transfer of exploration permit	12,500
Issue of mining permit	100,000
Administration of mining permit	actual cost

Source: Standard Terms for prospecting (MRA 11 March 1992) and for exploration (MRA 16 December 1991)

Taxable income is computed annually as total income from any activity or type of transaction. For firms with limited tax liability, only income derived from the activity in question is liable, and only deductions related to that activity are possible. Income is determined using the arm's length principle, such that transactions between affiliated enterprises are adjusted to reflect normal commercial conditions (in order to prevent transfer pricing). Depreciation can occur immediately or be deferred to later years, depending on the preference of the firm. Dividends are allowable deductions for companies with full tax liability, (but are taxed with the shareholder, at 35% if the shareholder is a licensee under the Greenland Mineral Law). If taxable income is negative, the amount may be carried forward until offsetting positive income occurs, or it may, upon special application, be carried backwards. Two special deductions are available. One is for funds set aside for implementation of the abandonment plan, and the other is for further processing of mineral concentrates in Greenland, at 10% annually of the investment in plant and equipment for such secondary processing. This deduction is apparently available for an unlimited number of years. For the computed tax-base, the current tax rate is 35%. There are no withholding taxes on dividend payments to foreign shareholders.

Petroleum permits provide for a royalty of 5% of the value of liquid hydrocarbons for (total) quantities in excess of 79,5 million m^3. The value is to be determined in relation to a

standard crude product (Brent Blend, fob., Sullom Voe). For production less than the 79.5 million m^3, the royalty is set at 1%. In addition to the royalty, however, there is a state participation clause. Under this, Nunaoil A/S will participate with a 15% share in any project on a carried interest basis. In a production phase, defined to begin when a development plan has been approved, Nunaoil will not be carried. The private partners can be required to purchase Nunaoil's share of production at reasonable terms which reflect market prices.

For petroleum a separate set of rules and procedures has been prepared. Work requirements are listed in table 7.3, and the most important terms can be summarized as follows:

1. Maximum exploration area consists of 6 blocks each made up of 25 sub-blocks (total area up to approx. 2,400 km^2;

2. One fourth of the area must be returned at the end of year 6 of the permit, a further 25% must be returned in year 8;

3. The term of the permit is 10 years, with up to 3 extensions of 2 years each;

4. The permit can be terminated by the permitee at the end of any year, provided exploration requirements have been met;

5. A number of fees are payable. In the production phase permitees contribute the cost of administration to the MRA;

6. If a viable deposit is found the permit can be extended, for the area in question, for a period of 30 years;

7. Nunaoil will have a 15% share in any project, carried during the exploration phase;

8. Royalty will be 1% of the production value for the first 500 million barrels, then 5%. Royalties can be waived if necessary for operations to remain competitive;

9. In the event of production, an acceptable Environmental Impact Statement must be submitted.

TABLE 7.3. REQUIRED PETROLEUM EXPLORATION WORK

Year	Minimum work required	Minimum expenditure
1-3	250 km multi-channel reflection seismics per block.	Minimum work per block: $US 0.55 mill. Minimum work per permit: $US1.65 mill.
4-6	1 exploration well to basement (or 3500 m.).	Minimum work per permit: $US 30 mill.
7-8	1 exploration well if less than 50 subblocks are kept;	Minimum work per permit: $US 30 mill.
	2 exploration wells if less than 100 subblocks are kept;	Minimum work per permit: $US 60 mill.
	3 exploration wells if more than 100 subblocks are kept.	Minimum work per permit: $US 90 mill.
9-10	1 exploration well if less than 30 subblocks are kept;	Minimum work per permit: $US 30 mill.
	2 exploration wells if less than 60 subblocks are kept;	Minimum work per permit: $US 60 mill.
	3 exploration wells if more than 60 subblocks are kept.	Minimum work per permit: $US 90 mill.

Source: (Mineral Resources Administration for Greenland 1992c)

Environmental protection

All matters of environmental protection related to mineral activities are regulated through the Greenland Mineral Law, and through the Standard Terms for various types of permit. The general power to issue regulations on environmental matters is contained in section 24 of the Mineral Law (Mineral Law 1991): "The minister can issue regulations for activities governed by permits issued under sections 6 and 7 of this Law...including regulation of technical, safety, environmental and resource conditions"[57].

These powers are implemented through the regulations for the permitee's conduct during, and after exploration activities. The rules of conduct which are collected in a separate 60-page booklet includes both environmental protection rules and regulation of other aspects of the exploration process. The former specify what types of equipment may be used, and activities undertaken without separate permission from the MRA. The rules also imply that permitees have a general duty to minimize the environmental impact of exploration on landscape and vegetation. The general principle for ending exploration projects is that sites must be left in the condition they were found (i.e. all installations must be removed, and all damage to nature repaired).

[57] Authors translation. Regulations of technical, safety and resource conditions have not been issued.

When a production decision is being made, section 14 of the Standard Terms for exploration permits requires the permitee to prepare an environmental impact assessment (hereafter "EIA"). The content of the EIA must be approved by the MRA, and then submitted during negotiations with the MRA concerning the detailed planning and implementation of the development and production phase (Mineral Resources Administration for Greenland 1992e).

ON THE CONTENT AND SUFFICIENCY OF THE 1991 POLICY REFORM

Mineral policy in Greenland exhibits incomplete understanding of the nature of the mineral industries. The problem seems most acute in the case of mining regulation, while petroleum policy appears generally more assured. This may be explained by the fact that Danish administration has considerable knowledge in relation to petroleum in the North Sea, but virtually no experience with mining.

The following sections analyze four areas where serious problems exist. The first is the political and administrative organization. The second treats the discrepancies and ambiguities found in the existing regulatory framework. The third area of concern is taxation, where policy credibility plays an important role. Fourth is the matter of emphasis placed on petroleum resources, and government investment in mineral exploration.

Political and administrative organization

The argument about who "owns" the resources has had unfortunate consequences. It seems that the importance of mineral rights has been overly dramatized when in fact these rights are little more than leasing contracts. In other words, the amount of control given up by issuing a permit is limited. It can be argued that the legalistic preoccupation with control, for example in the event of severe energy shortages which would activate international treaty obligations on energy supply, has legitimized a refusal to view the operation of market forces in relation to mineral rights as the normal and preferable allocative mechanism. The energy-treaty argu-

ment is, however, a remote possibility under most circumstances. A more plausible explanation is that Denmark wanted to retain some control over the only reasonable chance of recovering some of the vast sums Greenland has received in net unrequited transfers over the years.

In terms of political influence on policy formation as well as on permit decisions it is clear that the Joint Committee plays an important role[58]. Several observers have noted, however, that the MRA is equally or more important than the Committee (Davis and others 1984; Harhoff 1993).

The concentration of knowledge within the MRA, and before it the Ministry for Greenland, has a long history but it only became an issue when Greenland itself became an interested party, as Home Rule was introduced. The fear in Greenland of an "information monopoly" has been noted above. The solution desired in Greenland is to have the MRA located in Greenland as part of the Home Rule Administration (this can be seen from statements made by Greenland's Premier, Mr. Lars Emil Johansen, in the course of a recent debate on mineral policy[59]), but that raises exactly the same problem, with Greenland and Denmark in reversed roles. The natural solution is to place the MRA directly under the Joint Committee, but this has never been seriously considered (Harhoff 1993).

The importance and influence of the MRA has been investigated by Davis and co-workers (Davis and others 1984). Their analysis[60] confirm the high concentration of information at the MRA, and the MRA's ability to control, and shape the information provided and the agenda of the Joint Committee. This conclusion is supported by Harhoff (1993), who argues that, because the Joint Committee is dependent on the MRA, the latter can influence the

58 The recommendations from the committee are always followed by both governments, as can be seen in the annual reports from the Joint Committee. It is, however, difficult to determine the extent of discussions taking place at the closed Committee meetings (minutes of the committee meetings are not available to the public).

59 Minutes of the Greenland Landsting, April 27, 1993, item 13.

60 This was based on detailed questioning of members of the Joint Committee.

Committee's decisions. This necessitates a loyal cooperation between the MRA and the Committee.

Discrepancies and ambiguities in the reformed mineral policy

The various regulations issued by the MRA in the form of "Principles and Procedures", "Standard Terms", etc. contain numerous discrepancies and ambiguities. The first can be found in part A of the document "Principles and Procedures" (Mineral Resources Administration for Greenland 1992d), and concerns the priority given to a holder of a preliminary investigation permit. When two or more parties apply for an exploration permit for a given area, "....priority will be given to that party who has conducted exploration in the area applied for, and who has reported in writing [to the MRA], a discovery of possible economic significance, and who thereby has established a basis for further exploration"[61].

Thus a preliminary investigation permit, which does not otherwise imply any special right, takes on such rights when there are more than one applicant for an exploration permit. However, this happens only when three conditions are met: prospecting must have taken place in the area applied for, a "discovery" must have been reported, and the basis for exploration must have been established. The interpretation of these rules is difficult. It is unclear whether the exploration must have taken place in the area applied for, or just in the area of the preliminary investigation permit. The concept of a "discovery of possible economic significance" is not defined, and it will be difficult to asses whether a permitee has established a "basis for further exploration". These omissions create an incentive for holders of preliminary investigation permits to report anything which may be of economic potential. In extreme cases, with heavy prospecting activity in an area, each permitee will report any anomaly, in writing, in order to protect his investment. Even if things are clear up to this point, there is still the possibility that two holders of preliminary investigation permits have done all the correct

61 Author's translation. The preferential status applies for a period of 6 months after the end of the permitee's field program.

things to obtain preferential status. There is no way of determining how the conflict between these will be resolved[62].

In "Principles and Procedures", both part A on general issues (section 2), part B on preliminary investigation permits (section 3), and part C on exploration permits (section 3) contain explicit and very detailed descriptions of the timing of issuance of permits, and the term of the permit. These rules mean two things. First, no exploration permits will be issued for areas covered by a preliminary investigation permit during the months of July, August and September, in order to allow holders of the latter type of permit to apply for an exploration permit themselves. Second, if a permit is issued before October 1st, that year will be year 1 of the term, which runs to December 31st in year 5. If permits are issued after October 1st, the following calendar year will be year one.

These rules are unduly complicated and also unnecessary. The first rule is designed to give a holder of a preliminary investigation permit protection during the field season (Mineral Resources Administration for Greenland 1992d). Both this and the priority rules discussed above indicates the ambiguity associated with this type of permit. On the one hand section 6[2] of the Greenland Mineral Law specifies that a preliminary investigation permit can be given to more than one party for the same area. On the other hand the "Principles and Procedures" document gives a number of rights and exemptions from the general rule. Rather than having a type of permit which is ill defined, there should be a clear distinction between preliminary prospecting activities involving no rights, and "proper" exploration rights which are exclusive to the holder.

A special form of permit is available for individual prospectors which meets this requirement. Unfortunately, the section providing for this personal permit is worded in a highly confusing

62 The event which can precipitate this problem is the discovery of a major orebody. Once this becomes known, other prospectors will rush into the area and try to obtain control over ground adjacent to the discovery.

way (Mineral Resources Administration for Greenland 1992d). Section 7[1] reads: "A special personal preliminary investigation permit can be issued to an individual who intends to prospect on his own account, and at his own risk - i.e. conduct prospecting which does not involve employment or contractual relations with others....."[63]. There is little doubt that this provision has been made with the intention of promoting local participation, and eventually develop a prospector culture in Greenland. Unfortunately, it is very difficult for individual prospectors to exist in a vacuum. The prospectors business is based on the information he can produce and sell. If a prospector cannot enter into contractual agreements, as prohibited by section 7[1], the prospector's permit is meaningless. If the intent with this restrictions is to prevent individuals from subcontracting work from mining firms this should be more clearly stated, and such a clause should then also specify whether the prospector could employ others. In any case, there is no record or mention of the "prospector rule" having been used.

The rules for exploration work requirements are outlined in "Principles and Procedures" (Mineral Resources Administration for Greenland 1992d), and elaborated further in the "Standard Terms" for preliminary investigation permits and exploration permits, respectively (Mineral Resources Administration for Greenland 1992e; Mineral Resources Administration for Greenland 1992f). While the general progression, as shown in table 7.1, is comparable to for example Canadian mining legislation[64], it reflects a strange conception of diligence provisions.

The obligation to carry out the required amount of exploration (section 6 in the standard Terms for exploration permits) rests on the holder of the permit. The Standard Terms emphasize that work carried out before a permit changes hands cannot be counted as work by the new permitee. In "mainstream" Mineral Laws, as expressed for example in Canadian provincial Mineral Laws, the work required to keep a mineral title in good standing is related to the

63 Author's translation. These permits are valid for one calendar year and require payment of a 1,000 DKr fee.

64 British Columbia Mineral Tenure Act Regulations, Section 19 (B.C. Reg 297/88).

title itself, not its owner. In addition, it is not clear from the Standard Terms how a new permitee will be placed on the scale of increasing work requirements.

Exploration expenses exceeding the required amount can be carried forward for up to 3 years. It is unclear whether unused exploration expenses can be concentrated on a smaller area, when the area of the permit is reduced. Grouping provisions allowing this are also common in Canadian mineral legislation.

It might be argued that it does not matter whether exploration expenditures follow the firm or the permit: the value of contract for the transfer of the permit to a new permitee will reflect the lack of transferability. On the other hand it might be argued that valuing the real information contained in an active exploration project does not need further complication. The problem with linking work requirements to the firm, and not the land is that it may encourage redundant exploration expenditures, as discussed in chapter 4.

The structure of the Mineral Law is also ambiguous on the question of state participation. Section 8[2] gives the Minister the power to make such participation part of the conditions for a permission to explore and produce. For metallic minerals, section 16, limits this power to cases where explicit provision has been made for state participation in the exploration permit, or where a permitee has been made exempt from taxation under section 8[3] or similar provision in the Greenland Income Tax Law. For petroleum, the minister's powers to require state participation remains.

For all practical purposes, state participation in mining projects cannot be required, as specified in section 16 of the Mineral Law. However, given the structure of the Law, it stands out as the general rule. For mining a departure is then made, but only in certain cases. The fact that the participation rule has been placed in chapter 3 of the Mineral Law, which contains general rules for exploration and production permits, indicates another inconsistency. If the purpose is to use the rule only for petroleum permits, why was it not placed in the chapter (chapter 4) dealing specifically with this area ?

The standard Terms and the rule-book for preliminary investigation and exploration permits are very specific about which activities are allowed during exploration, and which are not. They are much less clear about what happens in the event of a discovery, except by specifying that a satisfactory EIA must be submitted as part to the permitting process.

The rule-book covering various types of exploration activity is extremely comprehensive. It contains primarily environmental protection rules, but includes a number of rules for reporting, safety and communications as well. Many of the latter refer to current regulations in Greenland (these the permitee must obtain and comply with). In general the practical rules are sound and sensible. There is, however, a large number of repetitions, and some sections (e.g. on driving on ice and on glaciers) could well be shorter and less patronizing.

The environmental rules are wide in scope, covering such diverse areas as storage of fuels, archeological sites, camp-sites, waste materials and site rehabilitation, as well as the use of vehicles and aircraft. In most cases the rules appear intended to secure near-complete restoration of any disturbance of natural conditions resulting from exploration activities. In a small number of areas in Greenland the use of aircraft is specifically regulated in terms of minimum flying altitude, frequency of flights, and periods of applicability, in order to protect specific species, including birds, muskox and polar bear. In other areas, however, some restrictions apply in areas with "rich animal life". It is very difficult to asses the relevance of such rules. It is likely that they are well founded on biological considerations, whereas it is less likely that the relative values of disturbing animal life, and minimizing exploration cost have been considered (if this is at all possible). The special rules which govern use of aircraft reflect the problems inherent in environmental regulation of mineral activities.

First is the information problem. The specific restrictions noted above apply in 3 limited areas in Greenland. The emphasis on these areas does not indicate that they are the only places where a rich animal life is found, but rather that information happen to be available about these areas. Given that the areas with explicit regulations have all recently seen explo-

ration activity (Mineral Resources Administration for Greenland 1991; Mineral Resources Administration for Greenland 1992a), it is likely that the information on which the regulations are based was acquired as a result of the interest in the area. If there had been no activity there would have been no need for data, and none would have been collected.

The relationship between information and mineral titles can be illustrated by the following story. Consider an area covered by an exploration permit. As exploration proceeds two things become clear: the area hosts a "world-class" nickel deposit, and one of the three known nesting colonies of a rare bird. If the deposit is developed it will be a great threat to the bird. And if the bird is protected, it will be the end of the mining company. The only two ways the situation could have been prevented was if the government had not issued the permit, or if the company had realized early on, that the bird was a potential obstacle.

The story highlights the problem facing both investors and regulators: environmental constraints may prevent the development of discoveries, and the investment in information about the deposit will be redundant[65]. With full knowledge about environmental resources and their value it would not be difficult to set up a framework of environmental regulations related to the sensitivity of different areas. By establishing such a framework, and integrating it with the way mineral titles are issued, a country can in fact create a high degree of protection for the investor. This can then be used in the competition to attract mineral investment. In most cases, however, information about the environment is highly imperfect, and becomes known only when some external event prompts its acquisition.

There appears no easy way of solving this problem. Some countries may have sufficient information to implement the land use planning approach discussed in chapter 5, where prospectors must observe the rules of conduct applicable in a given zone, and evaluate their re-

65 In some cases the government may compensate owners of a deposit if their title is expropriated for other use of the land (e.g. as wilderness). However, strict environmental regulation may have the same effect but without compensation being paid.

sults in the light of general environmental constraints applicable in that particular zone. Unfortunately, in most places lack of information makes such an approach very difficult.

Finally, there is the problem of what is left unsaid in the various regulations. It arises from the fact that some exploration projects leads to the discovery of mineral deposits which are economically marginal. Such deposits may eventually move into the "economically mineable" category, for example as a result of technological advances or price increases. Under the rules discussed above, however, there is no provision for such cases. A permit can be maintained in good standing by continued exploration (or by direct payments to the MRA). It cannot be converted to a production permit because it cannot obtain a bankable feasibility study. As a result the asset (the marginal ore and the information about it) will revert to the state.

Taxation and credibility

The special provisions for taxing mineral companies were noted above. Mining companies pay a flat rate of corporate tax, whereas petroleum production is also liable to pay a royalty, and accept a degree of state participation. The mining tax terms in particular appear very inviting. Comparisons with other tax regimes reveal, however, that most less developed countries have some form of provision for taxing additional profits.

Table 7.3. indicates that Greenland is more attractive in tax terms than many of the other countries which have a more enticing geological potential. The question is, however, whether so simple a tax will be seen by investors as permanent. If mining firms think that the tax rate will be changed they will base their decisions, not on the present tax rate, but on what they expect it to be. When seen in this more dynamic perspective, Greenland may not appear as attractive, as it would like to. The problem can be described by borrowing a concept from price theory, the "rational expectations hypothesis" (Muth 1961). This is the assumption that firms will utilize all the information available to them to predict the future price of a product. In this case the "price" is the rate of taxation on mining profits.

TABLE 7.4. SUMMARY OF MINING TAXATION IN SELECTED COUNTRIES

Country	Corporate tax rate	Capital allowance	Loss carry-forward	Additional profit tax	Withholding taxes[b]
Australia	39%[a]	Accelerated depreciation	Indefinite	No	Dividends: 15-30% Interest: 10%
Canada	34%[a]	30% of pool, development cost 20% of pool, machinery cost 100% of pool, exploration cost.	7 years 3 years back-ward	No	10-25%
Chile	32.5%	Straight line over useful life (some agreements for accelerated depreciation).	Indefinite, adjusted at cost of living index	No	Dividends: 32.5% Interest: 40%
Papua New Guinea	35%	Residual divided by remaining life of operation, or by a fixed factor, whichever is the lesser.	7 years	35% of accumulated value of net cash re-ceipts. Accumula-tion rate is 20% or average US prime rate + 12%. Adjustment for cur-rency fluctuations	Dividends: 10% Interest: 30%
South Africa	56%	Capital cost fully deductible in the year incurred. Unused depreci-ation can be carried forward.	Indefinite	33.3% of undistributed profits	Dividends: 15% Interest: Nil
Tan-zania	22.5% yrs 1-4; 50% from year 5	40% in year 1 10% in each of years 2-7 Benefication allowance: 20% of capital cost and 15% of operating cost of further processing facili-ties.	Indefinite	APT payable on net cash flow in excess of that needed for a threshold rate of return	Dividends: 10-20% Interest: 12.5-20%
Zimbab-we	45%	Current capital cost deductible in year incurred. Special concessions for new mines.	Indefinite	No	Dividends: 5 or 20% Interest: 10%
Green-land	35%	Capital cost fully deductible in the year incurred. Unused depreci-ation can be carried forward.	Indefinite	No	No

Notes:
a. Effective average tax rate
b. Depends on double taxation treaties
Sources: Corporate taxes: A Worldwide Summary, Price Waterhouse, London 1990, Kumar, 1991, MRA, 1992.

The experience in the mining industry seems to be that tax regimes are stable only as long as profits remain moderate (i.e. not far above the returns on other assets). If mines suddenly begin to earn large additional profits the state will be tempted to demand a share of these. The cases of the Bougainville re-negotiation (Pintz 1984), and lately the forced change

in ownership in the Porgera project[66] are clear illustration of this experience. Even the agreement on the 1935 cryolite concession shows that the idea is neither recent nor foreign to Greenland.

Given the uncertainty associated with a tax regime investors may perceive as incomplete, some sort of provision for taxing additional profits should be made, for example along the lines discussed in chapter 4 (see also chapter 8).

Emphasis on petroleum investment

The investment by government in different types of exploration activities in Greenland was summarized in table 6.1 for the period 1986-1994. It is clear that considerable emphasis has been placed on petroleum relative to metallic minerals. It is questionable, however, whether this has been an entirely wise policy. Exploration activities undertaken by government rather than by private investors indicate that the government believes that markets are not working properly.

It was argued in Chapter 4 that government exploration or subsidies for exploration could be motivated by excessive pre-sale exploration, or by higher than normal risk in exploration. The first argument was qualified by reservations about the efficiency of government exploration, while the second was dismissed primarily because the risk could be diversified. In practical terms the apparent need for government provision of basic geological information was explained by the sunk cost nature of much of the information and of the titles acquired to protect the investment during exploration.

The most important argument in favour of government exploration, reduction of pre-sale or pre-disposition exploration, requires that the problem is present. This is not the case in Greenland. If the high-risk argument is accepted for a moment, Greenland petroleum explo-

66 Mining Journal newspaper, March 19th, 1993. The dispute arose over large increases in the reserves and profitability of the mine. The Government of Papua New Guinea forced the other partners in the project to sell a total of 15% of the equity to the government, the cost to be financed out of after tax proceeds to the government share.

ration certainly fits the description. But the risk [relative to expected returns] is high only compared to other areas with petroleum potential. Thus it can be argued that the absence of private exploration in Greenland reflects not any form of market failure, but rather the opposite. Government exploration can then be explained only as pure subsidization.

In relation to the present case it is unfair to judge the investments in petroleum exploration solely on the above criteria. The funds used for the two major off-shore seismic campaigns in 1990-92 came from a savings account in which the MRA had placed the revenues from the Jameson Land concession from 1986 to 1990 (Ministry of Finance 1986; Ministry of Finance 1990). It is probable that this account was not immune to the attentions of the Finance Ministry, and they had to be used before they were directed elsewhere. This interpretation is supported by the fact that this account was also used to finance the Danish government's share in the equity expansion of Nunaoil A/S (Mineral Resources Administration for Greenland 1992a; Ministry of Finance 1991).

With respect to the policies adopted for petroleum it is difficult to asses whether the terms and conditions offered are competitive. However, the combination of a 35% corporate tax, a royalty of 5% (initially 1%) and a state participation of 15% on a non-carried basis, appears very moderate compared to the terms in the Danish sector of the North Sea. Corporate tax there is 34% (down from 50% a few years ago), and no royalty. In addition, a form of APT is payable on profits after an investment allowance which allows operators to deduct 25% of total investments annually for 10 years (Arbejdsgruppen vedrørende kulbrintebeskatning 1992).

None of the observations made so far in this section explain whether all the attention and effort involved in preparing a licensing round, such as the one held for the West Greenland Shelf areas South of 66°N in 1992 (which did not attract any interest (Mineral Resources Administration for Greenland 1993)), was justified. Examination of the latest annual report of the

Joint Committee reveals that the decision to proceed with the licensing round was based on a single argument.

The initial realization presented is that exploration for petroleum during the 1990s can only be expected to occur in the off-shore West Greenland area. This was first signaled to the petroleum industry in January 1991. The Joint Committee formalized this by proposing a number of initiatives (Mineral Resources Administration for Greenland 1992a):

1. A first licensing round for areas South of 66°N to take place in 1992-93;
2. That the model permit be used (terms outlined above);
3. That the preparations be made for later rounds in the West Greenland shelf area.

The geological assessment of these areas were, based on limited seismic work, and exploration carried out during the 1970s, very ambiguous. The data indicated the existence of possible host structures for petroleum and natural gas, but these conclusions were considered highly uncertain. In addition, knowledge of the general types of source rock in the area, as well as experience from wells on the Labrador shelf, indicated that the area was more likely to contain gas than oil. Given the transport problems associated with gas this resource was considered without economic interest (Mineral Resources Administration for Greenland 1992a). Consultants to the MRA have judged the area of potential interest to the petroleum industry, provided the terms offered are sufficiently attractive. They have also stressed, however, that significant technical advances in production technology must be achieved before any discovery is exploitable (Mineral Resources Administration for Greenland 1992a).

According to the MRA, the essential reason for proceeding with the licensing round is the need to test the level of interest. This need is apparently stronger than the reservations noted above (limited knowledge, non-existence of production technology). A further argument advanced by the MRA in favour of initiating the licensing round is that experience gained in the first round will be important in later rounds. Finally the MRA outlines the ex-

pected timetable for subsequent rounds. This is expected to provide an added incentive for investors to take an interest in the first round.

Based on the statements from the MRA and the Joint Committee it can be concluded that the decision to start a sequence of licensing rounds is based solely on the need to "test" the level of interest. If unsuccessful, "the consequences of such a situation [lack of response] are without greater importance for the area [in general], except that it will be necessary to wait some time before a new attempt to offer the [rejected] area is made"[67] (Mineral Resources Administration for Greenland 1992a).

None of the statements in the annual report from the Joint Committee reveal whether the alternative to the policy adopted has been considered. The alternative is not to begin any licensing rounds until such a time when technology and also price makes a round relevant. Similarly, the question raised by the lack of interest in exploration off-shore West Greenland has not been addressed by the Joint Committee and the MRA. This is whether the later licensing rounds should be postponed if the first round is unsuccessful.

The first round went ahead based on a need to "test" the level of interest. The logical consequence of the absence of bids is then postponement of further rounds until interest in the area is renewed. Given the technological constraints noted above, and the low likelihood of increasing oil prices in general (Adelman 1990), the waiting period could be quite long.
The 1992-93 annual report from the Joint Committee reiterates these arguments at length and adds that despite the lack of interest in the first round, and despite the possibility of similar results in the next round, the MRA is of the opinion that planned rounds in West Greenland waters should proceed as planned. Four reasons are given:

1. Exploration strategies are not static, but changes over time and across firms;
2. New data can improve assessments of the area;

[67] Authors translation. Additional clarifying remarks in square brackets.

3. It is important to maintain the attention of oil companies and contacts established with them, and to appear credible by keeping to the announced schedule;
4. Indefinite postponement of further rounds precludes testing the market.

These further arguments, which are uncharacteristically detailed for a statement from the MRA, are inconsistent and cling to the model of licensing rounds used in the past, and well known from the Danish North Sea licensing rounds. The first argument is true in theory, but must, in order to be applicable to the Greenland situation, take the current circumstances into account. This would primarily involve a more detailed analysis of oil companies investment strategies, and especially of the likely changes in oil prices. There is no evidence that such analysis has been carried out. Both the first and second reasons for continuing the planned rounds could be accommodated with a more flexible approach to the way licensing rounds are conducted. Here a postponement of the next round, for example for 5 years would be a solution which would not damage whatever credibility the MRA might have, while allowing new information to become available.

CONCLUDING REMARKS - WHEN POLICY IS REACTIVE

The process of making mineral policy in Greenland consisted of a number of phases, starting in earnest with the enactment of the 1965 Mineral Law for Greenland. Major changes were introduced at the time Home Rule was established in Greenland in 1979, while a number of modifications during the 1980's made Greenland an increasingly unattractive target for mineral investment.

During these years, the Black Angel mine was operating with considerable success, yet nothing was done to follow up this success, nor was any attention paid to the conspicuous lack of new exploration investment. The levels of investment noted in chapter 6, which are low by any standard, were only recorded from 1986 onwards. It seems that the opportunity to capitalize on being a mining country was missed.

Then in 1990, when it became impossible to ignore the rapidly approaching closure of the Black Angel mine, an effort to review the Mineral Law was launched. It is important to emphasize that this review came about primarily at the instigation of the Greenland Home Rule Authority.

The resulting changes in the mineral policy was primarily a clarification of taxation rules, removal of the option clause, and improved security of tenure. However, a number of important inconsistencies were noted above, as was a number of more fundamental problems related to the long-term credibility of tax policy and the wisdom of the investment strategy for publicly funded research in mineral resources.

These problems can, to some extent, be attributed to the recent implementation of many and far-reaching changes in both policy and regulations. It is possible, however, to point to a number of special circumstances which may also have contributed to the problems. First is the fact that the regulatory system has generally existed without the moderating presence of a domestic mining industry. A mining industry would bring out the practical problems arising from the ambiguities and inconsistencies discussed above. Thus there has been little opportunity for dialogue with the users of the system about the regulations coming from the MRA. Second is the fact that the members of the civil service in Denmark have had no exposure to the mining industry, and only limited exposure to the petroleum industry. Thirdly, the principle of staff rotation within each ministry means that the term in office of each case officer is limited to a few years. This means that the burden of carrying the accumulated body of experience about mining falls mainly on the department executives.

Finally there is the problem pointed out by Davis and co-workers (Davis and others 1984) whose highly detailed analysis of the organization of mineral resource management strongly emphasized the high concentration of information and resources at the MRA, and the ability of the MRA to control the information provided to the Joint Committee. While it is difficult to determine whether this situation persists, it is clear from the inconsistencies noted above that the MRA has been unable to provide clear guidance for the political decision-mak-

ers. This applies both in situations where the policies embarked upon by the Joint Committee have been inappropriate or misguided, as well as in cases where the MRA has failed to provide the information and recommendations necessary for a long-term mineral policy. The adoption of options for state participation in metallic mineral exploration projects, and the emphasis on petroleum exploration are two such cases, while the failure to realize the grave lack of investment in exploration shows a clear lack of understanding of the nature of the mineral industry.

The current mineral policy is not sufficient. Given the substantial problems described above, a further review of mineral policy is needed. Instead of being based on the efforts of an internal working group, which is given one month to report, the next effort should be based on a far more thorough review of how other jurisdictions have organized their mineral policy. In addition such a review must take into account relevant aspects of economic, legal and organizational theory.

8

A MINERAL POLICY FOR GREENLAND

The analysis of the current Greenland mineral policy and its administration in chapter 7 suggests either another extensive round of modifications to the 1991 Mineral Law for Greenland, or a completely new mineral policy, including a new Mining Law which deals only with mining operations, as well as new legislation covering petroleum resources separately. At the same time the organization of political and administrative functions should be considered. The present chapter is a detailed policy discussion and proposal. Each subsection ends with a set of recommendations summarizing the issues raised in the preceding discussion. In drawing up the proposal, six distinct principles have been followed.

The first and most important concerns the nature of the whole policy. As it is to be a policy for Greenland, and because the time will come when it will not be managed by the Government of Denmark from Copenhagen, the policy must reflect the concerns of both Greenland and Denmark, as well as the administrative capabilities available where the MRA is located in the future (most probably in Nuuk, Greenland). At the same time the new policy must take into account that Denmark retains an [economic] interest in Greenland's mineral resources, and is likely to continue to do so as long as Greenland receives net unrequited transfers from Denmark.

The second principle is that the policies adopted must conform as closely as possible to the concept of sustainability. Given the nature of the mineral extraction process, where some exchange of natural capital for manmade capital is unavoidable, this requires that both environmental and economic considerations are taken into account, particularly in relation to the efforts made to secure sufficient accumulation of capital in Greenland.

The third principle to be adhered to in the new policy is that Greenland should maintain and improve its ability to attract mineral investment. This implies not only that economic terms should be competitive relative to other countries, but also that other parameters influencing investor decisions must be chosen to make investment attractive. Parameters in this case include the regulatory framework in general, security of tenure, predictability of environmental regulations, and the availability of necessary inputs.

The fourth principle is that the policies adopted should promote economic efficiency such that the net benefits in which Greenland can share are maximized.

The fifth principle is that government revenues should be maximized subject to the constraint imposed by the need to be competitive, and to the fact that full capture of mineral rents is very difficult to achieve.

The sixth and final principle is that attention should be concentrated in the area where Greenland has the greatest likelihood of finding viable mineral deposits.

The need to concentrate on the area where Greenland has the greatest potential for attracting investment, and discovering mineral resources, must be recognized. It was argued in the previous chapter that the logical consequence of the lack of interest shown in the 1992-93 petroleum li-

censing round must be a postponement of future rounds, and a reduction of activities in the petroleum field until market conditions makes new activities relevant. The present chapter proceeds with an analysis of what the objectives of a mineral policy should be, both in quantitative, and in qualitative terms. After a discussion of political and administrative organization, the design of a mining policy then takes up three principal areas of regulation: economics, technical and environmental. The analysis and discussions of these areas will overlap one another, since the instruments are closely related. For each of these areas the exposition in chapters 4 and 5 forms the basis for the discussion and recommendations.

POLICY OBJECTIVES

The first element of any mineral policy is to establish a consistent set of objectives. These can be framed in either quantitative or qualitative terms. To be comprehensive, the former must be specific and detailed, and will therefore also be inflexible, whereas the latter can be both flexible and comprehensive. Here we examine each in turn, and argue that a qualitative approach is preferable.

Quantitative objectives

When quantitative goals are set, they can apply, and be measured, at different stages in the mining cycle, and with the use of various measures of success. For metallic mineral exploration, this can be number of geochemical or geophysical anomalies (departures from background values, e.g. in gravity or electromagnetic field measurements) recorded or tested. In the production phase, the number and size of mines, the value of mineral output, and mining employment are all possible measures, as are the revenues of government.

Using quantitative measures is not, however, a superior approach. Defining objectives in such terms assumes implicitly, that some degree of control over the outcome can be exercised. In a world of highly mobile capital, the only instrument (apart from direct subsidies) govern-

ment can use to influence activity in the mineral sector is the bundle of terms and conditions, it can offer to investors. Other factors determining investment (commodity prices, technology, and terms offered by other jurisdictions) lie outside the control of individual governments. Thus, when an important part of conditions determining the outcome of a policy cannot be controlled, quantitative objectives lose some of their meaning. Furthermore, there is no guidance in quantitative objectives about what to do if the goal is exceeded.

In the case of Greenland, a set of quantitative objectives were formulated when the latest revision of the Mineral Law was initiated (Mineral Resources Administration for Greenland 1990). For metallic minerals, between 2 and 4 medium size operations (e.g. producing between 500,000 and 1,000,000 tons of ore annually), as well as a number of smaller ones, were considered sufficient to make a reasonable contribution to the local economy (Mineral Resources Administration for Greenland 1990).

Qualitative objectives

The alternative to quantitative objectives is to use a qualitative approach. In the mineral strategy report (Mineral Resources Administration for Greenland 1990), a general objective was to have a "separate [non-renewable] resource industry making a significant contribution to the Greenland economy"[68] This led to the statement of four qualitative objectives:

1. To attract investment in exploration and development by offering competitive terms and conditions;

2. To integrate a future mineral industry with other sectors of the economy, through employment, local downstream processing, and local investment participation;

3. To retain influence and control over resource development [in Greenlandic hands], such that development proceeds in a controlled way, and such that activities are conducted responsibly with respect to environmental, safety and resource concerns;

[68] Author's translation

4. To create a broad understanding and acceptance in Greenland society of mineral activities as a necessary part of the country's economic development, and of the costs and benefits of such activities.

These four objectives are a good point of departure for considering what Greenland wants from its minerals. Again, however, the implicit assumption is that government has significant control over events. The extent of this control depends on the views of government. Sometimes a high degree of intervention is favoured, sometimes not. In the short term, very extensive control can be exercised, for example over the conduct of operations, and the use of locally available factors of production and supplies. Short term regulation decisions requiring mineral firms to make decisions which are not based on market considerations will, however, adversely affect investment in the longer term, and it is advisable to avoid statements which can indicate that government intends to make such decisions.

Recommendation on policy objectives: To avoid ambiguities about the relative importance of the four objectives, Greenland should adopt a policy objective as follows:

> *"The purpose of Greenland's mineral policy is to provide terms and conditions for mineral investments which are internationally competitive, internally consistent, and safeguards the interests of Greenland"*

POLITICAL AND ADMINISTRATIVE ORGANIZATION

One of the strange features of the current mineral management system is the mixture of political and administrative decisions involved in the issuing of permits. Figure 7.2. outlines both the formal and informal process whereby mineral permits are issued. The discrepancy, between the stated procedure and actual functioning of the system, raises the question of how the mineral

management area is to be organized. The same can be said of the dual roles of the two agencies under the MRA, the geological survey (GGU), and the environmental agency (GM). The first of these roles is in applied research, which to some extent is based on a subsidy policy, whereas the other role is as advisor and inspector for the MRA. The sections below analyzes the organizational problems, and proposes a solution.

Political control - The role of the Joint Committee on Mineral Resources in Greenland

The creation of the Joint Committee was a compromise following from the Danish refusal to release control over mineral resources for reasons of sovereign control, and Greenland's demands for such control based on legal and moral rights. However, as noted in chapter 7, the balance between future independence considerations and the existing "Unity of the Realm" led to the current system of joint management. It follows from the fact that Greenland is likely to continue to receive transfer payments from Denmark for a long time, that Denmark will retain an economic interest in any resource projects. The natural consequence of this is that any change of the political organization must take the information asymmetry, inherent in the current organization, into account, and locate the power to issue permits with neither of the two governments.

The first part of the solution is to separate overall policy design from day-to day administration. The second part of the solution concerns the interests of the two parties. As long as both have substantial economic interests in mineral resources, these must [continue to] be jointly managed. From this follows the third part, that the administration should be under the joint control of the two governments, in order to avoid problems of asymmetric information.

The elements of a solution outlined here does not mention the Joint Committee, whose role in a solution, if any, must be considered. In its present form this body officially has an advisory role which is not clearly defined. On the one hand, such great store is set in its opinions that all matters of permit issuance are laid before the committee, regardless of the fact that it has no legal powers. On the other hand, three facts indicate that the role of the Committee in relation to permits is minimal. First, permits can be issued by the committee

chairman and his deputy chairmen. Secondly, by tradition the chairman of the committee is also the Premier of Greenland, and the Greenlandic deputy is a member of the governing party in Greenland. Thirdly, mineral resource issues are placed in the Greenlandic Premier's office. The conclusion, that in routine permit cases, the Chairman acts more in his capacity of Premier, and agrees to proposals for permits coming from the MRA (by implication from the Minister), is not unreasonable. If this is indeed the case, there is no need for the Committee to review permits afterwards, except possibly to make sure that a consistent policy is followed.

The solution proposed here is based on the three parts noted above, separation of policy formation from implementation, elimination of information asymmetries and creation of a true joint management approach. The model involves a simplified version of figure 7.1., with fewer involved entities (figure 8.1.)

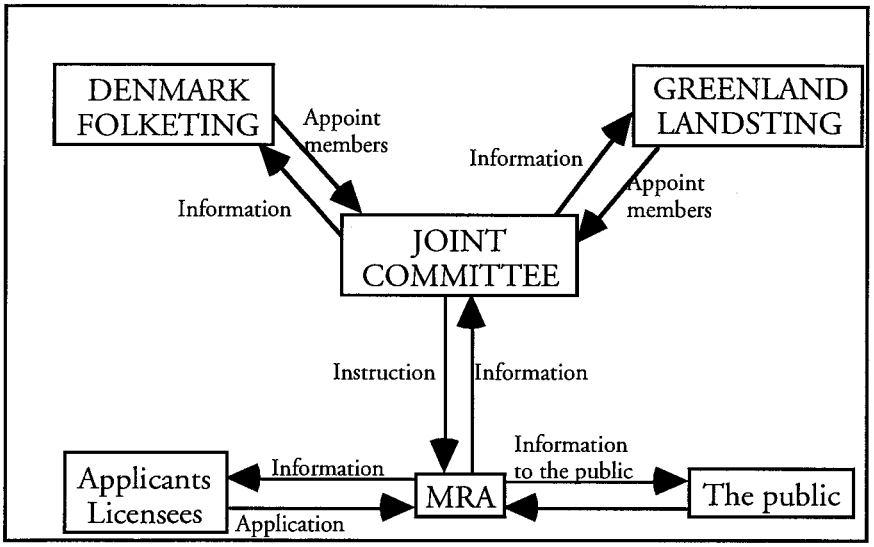

Figure 8.1. Future organization of mineral management in Greenland

It is important to note that in setting up this model the two parliaments, the Danish Folketing and the Greenlandic Landsting, must have full insight into and control over the actions of the proposed joint committee. Similarly, the members of the committee must be qualified to deal with mineral resource issues. and not necessarily be members of the respective legislative assemblies. The essential feature of the model is, however, that each delegation on the

committee is given a mandate to negotiate by the respective governments. Then it is up to the committee to determine a compromise (if such is needed), which is then to be approved by the two governments.

Recommendations on political organization:

[1] Retain the principle of joint management, and place the MRA under joint management;

[2] Separate policy formation from administration of the mineral industry;

[3] Create an advisory, review and monitoring role for the Joint Committee;

[4] Consider the capacities of appointees to the Committee, and possibly appoint experienced and respected individuals with knowledge of the mining industry.

Administrative organization

One of the strengths of the current regulatory system is that it is unified in its relations to the mining industry. All permitting and administration is handled through the MRA. The alternative is to let various aspects of the mining activity be handled by the ordinary administrative structure (e.g. environmental protection, and occupational health and safety in separate departments). The principal argument in favour of this approach is that it will treat mining firms in exactly the same way as any other firm. The alternative approach, as outlined below, is to have an integrated mining administration. With an industry above a certain critical size, the former solution has the potential of higher efficiency through a higher level of specialization within the environmental management side. For the time being the size of Greenland's mining industry is not sufficiently large to justify a well-informed environmental section outside the administrative structure, which deals with other aspects of the mining industry. The most flexible approach is to design environmental regulations to conform with current Greenlandic practice, thus facilitating a later transfer.

A successful transfer of the MRA to joint management, as proposed above, requires that a number of issues are resolved. These include definition of administrative tasks, the [physical] location of the administration (in Greenland or in Denmark), staffing levels, availability of qual-

ified staff, and definition of the relationship with the Home Rule administration and the Danish administration.

In terms of administration a list of specific tasks can be drawn up (table 8.1). These are not all relevant to Greenland's situation at present, but reflect future needs if mineral production becomes a reality. The second column in the table outlines the organization on which the following discussion is based.

TABLE 8.1. ADMINISTRATIVE TASKS AND THE ORGANIZATION OF THE NEW MRA

Activity	Department
General management Policy issues MRA budget and financial management Land management strategy	Executive office
Issue prospectors permits and exploration licenses Issue production leases Renew mineral titles Maintain records Approve exploration work credits	Mineral titles department
Review projects and EIAs Mine safety Environmental safety Training programs	Operations control department
Geological R&D (exploration) Engineering R&D Environmental R&D	Mineral resources research department
Taxation of mining firms Transfers to Greenland Transfers to Denmark MRA budget and accounts	Tax and economics department

The functions of each department are fairly clear. However, there will be some overlaps. Records of titles will, for example, be kept by the titles department, whereas specific information about site conditions will be kept by the research department. Similarly, there will be an overlap between the operations control department, which through its operations experience is best qualified to review projects, and the titles department, which issues the production permit. Finally it should be noted that the inclusion of "Land management strategy" is intended to vet [land]

areas before they are opened to exploration, such that highly sensitive areas may be excluded from access.

One of the purposes of using a functional organization is that this allows a much more comprehensive, integrated and efficient approach to complex mineral resource problems. In the early phases, the research department is to encourage a multidiciplinary approach to exploration. By taking geology, environment and engineering into account from an early stage, there will be good opportunity to asses the feasibility of projects at each stage, and early detection of projects which are stunning in geological terms, but impossible for environmental or engineering reasons will be possible[69]

The proposed organization is quite different from the present MRA and agency structure. The two major parts of the present administrative structure (the MRA on the one hand, and the GGU/GM complex on the other) are to be divided such that the MRA mainly falls into the executive and titles departments, while the GGU mainly falls into the research department, along with part of the GM[70]. Those parts of the GGU and the GM which deal with operational issues come under the operations control department. It is also important to note that taxation is also included in the new joint management model. This is in contrast to the present organization, where taxation of mining companies has been transferred to Greenland. The reason for including taxation is the same as for other areas, the possibility of information asymmetries, and the need for a unified and transparent organization.

The staffing of the new MRA is essential to its chances of promoting mineral investment in Greenland. However, in keeping with the need to keep the MRA under joint management, at least for the time being, the recruitment policy must reflect the two interested parties. Regardless of the origin of staff members, a comprehensive training program is essential for the staff to

69 For this approach to work it requires that the necessary environmental policies and legislation is in place, see below.

70 In practical terms it is essential to maintain the close links between the GGU and University of Copenhagen, a link which goes back to the foundation of the Survey.

be well acquainted with the administrative issues in the mining industry. Similarly the location is important. One of the frequently expressed goals of the Greenland political establishment is that the MRA should physically be located in Greenland[71]. The advantage of locating the MRA in Greenland is that it would make recruitment and training of Greenlanders less difficult.

Recommendations:

[1] Adopt a functional organization for the MRA;

[2] Tailor regulations to conform with general principles used in Greenland in different areas of regulation;

[3] Prepare the establishment of an administrative unit which can deal with all aspects of operations;

[4] Move the MRA to Greenland, but maintain the research department in Copenhagen;

[5] Provide new MRA employees with comprehensive training in mineral industry issues.

ECONOMIC POLICIES TOWARDS MINERAL FIRMS

The policies, used to regulate economic aspects of the relationship between exploration and mining firms and the government, consists of three areas. The first is the economic effects of regulations affecting the exploration phase. The second area is taxation of mineral rents and the incentives used to promote downstream mineral processing within the country. The third area of economic policies are those related to environmental protection. This area includes the provisions needed to secure an orderly closure and abandonment of a mine site when reserves are exhausted.

Exploration phase

Chapter 4 discussed some of the unfortunate incentive effects in traditional mineral leasing. In relation to mining, problems associated with diligence requirements ("use it or lose it") were noted as being particularly important.

71 The wish to move the MRA was clearly expressed when the Landsting debated the 1991 Mineral Law on April 15, 1991 (Mineral Resources Administration for Greenland 1991). It is more difficult to determine whether these statements imply that the MRA should be part of the Home Rule Administration.

The nature of mineral exploration information is such that it cannot, to a very large extent, be separated from the specific area to which it is related. For a firm the extent of its control over the area is therefore an issue of central importance. The firm will want to retain control if it has found, or expects to find, mineral deposits which are, or are expected, to be profitable to extract. In this sense the firm derives a measure of utility from having control, even if the deposit is not instantly viable.

The traditional approach to mineral title disposition, as seen from a government point of view, is that it is desirable to secure a vigourous search for minerals within the country (Bergstrom 1984). This may not, however, be true in terms of economic efficiency. The question of diligence requirements, which are used to force incumbent holders of mineral titles to explore the tracts they control, was examined in chapter 4 and it was argued that such requirements are unfortunate from an economic point of view. However, finding and alternative way of allocating mineral rights proved difficult. The alternatives were auction sale, giving away titles to anyone asking for them, and giving them away in return for a commitment to explore. The two latter possibilities also involve a system of ex-post payments to recover mineral rents.

Of these possibilities, giving mineral titles away without getting anything in return is irrelevant to the present discussion, since it is politically impossible. Adopting an auction is difficult for the reasons mentioned in chapter 4, and this leaves us with the existing approach. Within this the goal must then be to minimize the distorting effects of exploration requirements by making the mineral rights fully marketable, by allowing consolidation of work on smaller areas through grouping provisions, and by setting generally modest work requirements.

Recommendations:

[1] Retain the traditional first-past-the-post and work requirement system;

[2] Set work requirements at a level lower than competing nations;

[3] Allow reductions in permit area to concentrate documented expenditures on smaller areas;

[4] Facilitate transactions in mineral titles by minimizing bureaucratic procedures and eliminate special fees for recording transfers of title;

Production

In the production phase the question of rent capture is clearly the most important. A number of options are open to the government with taxing authority, ranging from royalties over simple corporate taxation, and some form of a Resource Rent Tax (RRT) to a combination of these. The choice between a combination of traditional corporate taxes and an additional profits tax on the one hand, and a single mining company tax on the other hand depends on how corporate taxation will evolve in the future. This is essentially a question of whether or not the corporate income tax will continue to exist. The basic finding of Musgrave (1959) is important here. He argues that if there is no corporate income tax then individuals will shift income to the untaxed corporate tax-base. The implication is that a corporate tax is necessary for this reason alone. However, even if capital if internationally mobile, the possibilities for income shifting and transfer pricing does not indicate that there should be no corporate income tax. In fact, the opposite is the case, as discussed by Gordon and MacKie-Mason (1993). They find that while in theory corporate income taxes in small open economies should not be imposed, the realities of income-shifting between personal and corporate tax bases, and between domestic and foreign subsidiaries, provide the reason for applying corporate taxes.

In relation to mineral taxation these problems cannot be ignored, and the discussion of rent taxation in chapter 4 indicates possible solutions. There are really two distinct problems: preventing income shifting and taxing windfall profits. This means that it is important to define the mining company precisely for accounting purposes and then applying the chosen tax.

With respect to the present tax regime in Greenland it was argued in Chapter 7 that the sole reliance on a corporate tax structure means that Greenland and Denmark is unable to deal with high unexpected profits. As a result the tax regime may not be credible from an investor point of view. The alternatives are to supplement the existing regime wit a small royalty and/or a form of RRT. The first option is attractive from a revenue-flow point of view, and if applied at a modest

rate may not affect production decisions adversely, whereas the latter is more efficient but also more complicated to apply.

The complications are partly a question of observing what the relevant costs and revenues are, in order to calculate the tax base, and partly a consequence of the problems inherent in the RRT approach. The analysis in chapter 4 highlighted two critical issues in the "standard" RRT. The first is that the simple RRT allows only expenses associated with successful projects as deductible cost, and the second that an accumulation rate in excess of the risk free interest rate will introduce a bias in favour of low-risk projects. An additional problem is to set the actual RRT tax rate.

One possible solution to the first problem was conceptually appealing. To avoid the distortion associated with denial of full loss off-set, exploration expenditure credits should be made tradable. The only drawbacks to this elegant solution are that the market for such credits must be competitive, that total profits exceed the sum of credits, and that credits can be used only once. Unfortunately, the first two conditions cannot be met in the case of Greenland as long as exploration activity is low, and there are no profits in need of exploration credits. Regardless of whether exploration credits are tradeable it may be possible to exchange them through inactive exploration companies which have accumulated the past losses of unsuccessful exploration projects. The simpler alternative to tradable exploration credits is to allow exploration companies to continue accumulating losses on exploration only until a successful discovery is made, and then reset the accumulation account to zero.

The second problem is related to the accumulation rate. To be consistent it must be set at the same level for all projects, but can be set above the risk-free cost of capital. If there is no provision for full loss off-set then it can be used to compensate this distortion. If full loss off-set is possible then the rate should be equal to the interest rate on government bonds.

The third problem can also be difficult. Because the RRT may discourage investment in exploration (because it cuts away the upper part of the probability distribution of expected returns to exploration), it may be necessary, at least initially to set the rate at around 50%, and

then modifying it depending on what other jurisdictions decide to do in the mineral taxation area, as well as on the effect the policy is observed to have.

Recommendations on taxation:

[1] Combine an ordinary corporate tax and a Resource Rent Tax or use a Resource Rent Tax alone;

[2] Adopt the simplified approach to full loss off-set;

[3] Set the accumulation rate marginally above the interest rate on government bonds (in Denmark), for example 3% above;

[4] Set the RRT tax rate at 50% of taxable income, and adjust it later;

[5] Allow ordinary corporate taxes as deduction for the calculation of RRT taxable income.

Closure and environmental protection

The traditional approach to securing compliance with closure and reclamation requirements is that the project operator must provide financial assurance that the required program can be carried out. The assurance can take the form of cash, letters of credit, bonds, or other form of security. The financial assurance can then be activated if the owner or operator is unable to carry out the reclamation program.

The use of bonds does not in itself introduce any incentive to optimize the reclamation and closure process, nor does it promote efficiency in environmental management during the productive life of the mine. To reach this type of goals one of the traditional economic tools in environmental management (taxes on emissions or tradable emission permits) needs to be activated. Given the nature of mining operations this appears a difficult approach. There are however, a few ideas which might be useful in this area.

The first is to try to charge a fee for the disposal of the most voluminous outputs of a mine, for example tailings, waste material, and process water. This can be done either based on volume deposited or, more simply, based on the area occupied by various types of waste. The emissions tax would then be charged in the form of a lease payment on land used for these purposes.

The second idea is based on a contracting approach. Here the operator accumulates funds for the final reclamation (for that is what happens when reclamation bonds are posted: the money is initially borrowed, but the loan is gradually paid of) until a sum determined by the government has been reached. When the reclamation proceeds the firm uses these funds for the reclamation, and is allowed to keep the remainder. The scheme requires that the government can monitor the standard of reclamation, and that it does not change the rules of the reclamation along the way.

Whether any of this can be applied to Greenland is another matter. In principle it is possible but the question is more one of determining the relative costs and benefits of reclamation (and other environmental safeguards as well) than of implementing the rules.

Distinct from the issue of permanent closure and reclamation is that of temporary closure. As noted in chapter 5 this type of closure is usually the result of short-term fluctuations in commodity markets, which make a suspension of production, or a sudden productivity gain, imperative. Thus the economic burdens facing a company at such a time should be minimized as much as possible. Apart from releasing the reclamation bond (which is unthinkable) this can be accomplished by not burdening a mine with "job security" constraints or other onerous charges during the temporary closure.

Recommendations on environmental provisions:

[1] Allow the mine operator to keep unused parts of a reclamation bond;

[2] Facilitate temporary closure as much as possible

[3] Adopt comprehensive valuations of mineral and non-mineral options in the project approval process;

[4] Consider alternatives to reclamation and closure bonds

TECHNICAL ORGANIZATION

In chapter 5 a number of technical regulations were discussed, ranging from land use planning over mineral titles to technical management of exploration, production and closure of mines. In the following sections we examine each of these functional aspects of mineral policy in relation to Greenland, and conclude each section by making specific recommendations.

Land use planning

The need for some form of land use planning was strongly emphasized in chapter 5. Without it, there is a risk that projects where a discovery has been made will be denied permission for development (in the form of a mining lease or mining license) for environmental reasons not known when exploration began.

The practical problem with land use planning in a country like Greenland is the sheer size of land to be covered. However, despite the considerable body of information needed for meaningful planning, some progress may be possible in this respect. By adopting a strategy of evaluating only those areas with a high potential for mineral discoveries (i.e. primarily those areas with supracrustal rocks) and reasonable ease of access, it should be possible to reduce the size of the area to be studied. These areas can then be classified into two or three categories:

- Land open for exploration with standard conditions;
- Land open for exploration under restrictive conditions (may be omitted);
- Land closed to exploration.

The land open for exploration with restrictive conditions should be thought of as land where mineral deposits, if discovered, are certain to obtain a mining lease or license, albeit this may also be on more restrictive terms than under standard conditions. The certainty that mining will be permitted, must naturally be accompanied by a general indication of the environmental conditions a project in a "restricted" zone must meet.

Recommendations on land use planning

[1] Adopt a simple zoning system with 2 or 3 zones;

[2] Concentrate zoning efforts in areas of high mineral potential

[3] Entrench the rule that if land is open for exploration then orebodies discovered can be developed.

Prospectors, prospecting and early exploration

Three issues dominate the early exploration phase. One is the nature of the permit to prospect, the second is activities a prospector may carry out and the third is the incentives associated with the first two.

The right to enter Greenland to explore for minerals is presently issued by the Mineral Resources Administration for Greenland to mining or exploration companies who apply. A personal prospecting permit is also available, but it is not well designed (see chapter 7). The distinction between individuals and firms is not necessary, nor is the practice of prescribing only a specified area where the holder of the "preliminary investigation permit" (and the name of the personal permit is pretty tongue twisting as well !). Instead, the early phase of exploration should not be tied to any specific area. Further, a "prospecting permit" should be available to any individual or firm wishing to prospect for minerals in Greenland, subject only to a simple code of conduct. The legal implication of a prospecting permit should be that it allowed the holder to enter on lands open for exploration, and enable the holder to apply for an exclusive exploration license.

The technical regulation of exploration activities was discussed in chapter 5, and the distinction between preliminary and advanced exploration was clearly whether or not the surface was disturbed by mechanical means. One other aspect of the environmental impact of prospecting is the handling of waste materials from camp sites. Such waste can be separated into that which can be incinerated on site, and that which can be buried. Although burial involves surface disturbance, this method will generally have very limited environmental impact.

In Greenland, as in other parts of the Arctic, use of vehicles in areas with soft ground conditions is likely to leave tracks which can remain for a very long time. Whether special regulation to deal with this type of problem is necessary depends on the both the loss resulting from the existence of such tracks, and the costs of avoiding them. This would typically be issue which zoning could deal with in a sensible manner.

The final aspect of prospecting is the incentives such activities may provide for local involvement in the mining sector. In contrast to the current regulatory framework which discourages local involvement, and discourages relations between individuals operating as prospectors and exploration companies, some effort should be made to encourage the former. Here I am not talking about moderately prized reward schemes to encourage submission of interesting samples, but of a more concerted training and assistance effort. This would have to include emphasis on relevant disciplines in the educational system, as well as special training courses for serious prospectors.

Recommendations on prospecting and prospectors:

[1] Design one type of prospecting permit; possibly graduated to permit entry into one type of zone only;

[2] Give access to all lands open for exploration;

[3] Restrict the right to apply for an exploration license to holders of a prospecting permit

Exploration license and advanced exploration

As noted above, the features which most prominently distinguishes advanced exploration from prospecting are those activities which involve significant surface disturbance (i.e. drilling, trenching, bulk sampling, underground work, and the construction of roads and other work areas). Whilst the time when the exploration company decides to undertake advanced exploration may be thought ideal for issuing an exploration license, this ignores the needs of an investor. Under the traditional approach to mineral title disposition (recommended above) investors have

to balance the need for exclusivity against the requirement to carry out exploration work, and the possibility of obtaining exploration credits (i.e. approved exploration expenditures which can only be approved if an exploration license has been issued). This implies that an exploration license should be available at any time.

An aspect important if the level of mineral exploration activity increases within a region or area, is who gets priority to obtain a license. This may seem an academic question given the very low level of activity in Greenland. However, experiences from other jurisdictions indicate that situations where many prospectors rush into an area in reaction to the news of a discovery are sufficiently well documented to warrant provision against such a situation.

If the purpose is solely to determine who applied for an exploration license first, then the time an application was received by the proper authority would be sufficient. Such simplicity may not be possible if the claims which individual (i.e. local) prospectors can make are to be taken seriously. This type of prospector is unlikely to have the same means of communicating as have exploration firms. The question is whether this should be reflected in a rule of priority. If some kind of lag in favour of independent prospectors is introduced then it becomes necessary to make all applications subject to a lag, and to make absolutely sure that no information on the location and identity of the area or the applicant (and also the very fact that an application has been made at all) is released to the public. If any kind of information was available about who was applying, and for what area, someone holding an individual prospectors permit (and thus entitled to be favoured by the lag) could apply for the same or an overlapping area and deprive the original prospector the opportunity to get an exploration license. The difficulty of keeping such information secret indicates that some other approach to recording priority in time is needed. The alternative is to rely only on the time when an application is made. This means that some form of marking out the ground applied for will be necessary, including some durable identification mark. This resembles the Australian practice of "pegging", where pegs or stakes on the site applied for are used to establish priority in time.

For the detailed technical regulation the distinction implied by surface disturbance is much more useful. In view of the principal areas of concern associated with surface disturbance noted in chapter five, regulations in the following main areas are warranted:

1. Separate permission required for the use of mechanical excavation and drilling equipment;
2. All excavations must be filled in if not used;
3. The holder of an exploration license must minimize the area disturbed;
4. Separate permission required for the construction of roads and airstrips on land;
5. All waste materials must be removed, burned or buried;
6. There must be no interference with historical sites.

In restricted zones these outline regulations could be supplemented by rules requiring more extensive reclamation or re-vegetation following surface disturbance, as well as more comprehensive removal of waste, more careful storage of supplies, etc.

In chapter five attention was drawn to the use, in some Australian jurisdictions, of "exploration retention licenses" in situations where an orebody could not, for some reason, be brought into production immediately. Having such an instrument available in a Greenlandic context, where deposits may be marginal for a number of technical reasons related to the extreme climatic conditions, will be an important part of a strategy designed to allay investor fears over security of tenure.

Finally, the matter of information and reporting. It has been argued at some length in chapter four, that the public goods nature of parts of the information generated by exploration can create a problem of free-riding by less serious explorationists, (if the information cannot be kept private). At the same time government has an incentive to acquire the information for inclusion in a permanent information base on national resource endowment. The latter consideration always leads to an obligation for explorers to report all of their results, and sometimes also deposition of

samples and drill cores. The typical restriction is that the information is confidential as long as a mineral title remains valid. However, given the possibility of such information having public goods value, it is more natural to make the information accessible to others, so that new ideas can be tested. It is clear that Greenland should continue it's preservation of geological and exploration data. In order to allow the full public goods value of the information to be realized, there should also be a mechanism enabling others to access the geological information about a given tract. The reason this can be allowed is that incumbent firms, because they are assumed to be rational, have maximized their utility from the information they have acquired. Thus, in relation to recorded property rights the protection given by the mineral titles system should be sufficient protection. The most fruitful approach is not, however, to make information accumulated in a government database freely available, but instead to facilitate trade in information between firms with existing titles, and entrants with new approaches or exploration models. Trade in this way allows the incumbent to maximize the value of his accumulated information, while the entrant can acquire pertinent background information without always repeating the work done by an incumbent.

Recommendations on exploration licenses

[1] Make an exploration license with exclusivity available to any holder of a prospecting permit;

[2] Let priority to obtain an exploration license depend on the date and time when an application was filed;

[3] Issue standard regulations for the conduct of exploration work in standard and conservation zones;

[4] Adopt an exploration retention license for marginal deposits;

[5] Introduce a framework which facilitates trade in exploration information;

[6] Allow free access to government-held information when titles have lapsed.

Development approval procedures and project operation

The need to guarantee an investor that once he holds an exclusive title (exploration license or exploration retention license) he will be able to develop any mineral deposit he may discover, has

been emphasized repeatedly above. However, as a result of the very incomplete information base prior to exploration, the right to develop cannot exist independently of society's need to determine and enforce a certain level of environmental protection. This implies that the right to develop can never be absolute, or unconditional, even within a system where land has been classified in broad zones.

Some mechanism is therefore needed to determine precisely what environmental constraints each project will be subjected to. The alternative is to devise an elaborate system of regulations which seek to cover all possible mining situations. As discussed in chapter 5 this is not appropriate for a small and inexperienced mining country like Greenland. The basic nature of the mechanism proposed here is that of a project review, albeit somewhat different from the one described from British Columbia.

First of all the commitment to allow mining implied in the land use recommendations made above must be qualified at the outset (i.e. before exploration commences) by a statement to the effect that any future mine development will be subject to a *reasonable* set of environmental constraints. One of the objects of individual project reviews is then to establish for the government a reputation for reasonableness.

The first element in building a reputation, which does not compromise a politically acceptable threshold, is to determine a set of constraints, defined in terms of the most commonly occurring environmental impacts of mining, which cannot be exceeded. Although this approaches detailed regulation the intention is to identify only the major types of impact, and set rough maximum allowable emission targets. Determining these impacts then becomes the key to subsequent regulation, and the process should ideally be based on a careful scientific and economic analysis of the major impacts, and the possible ways of mitigating them.

The subsequent steps in building a reputation depends on the ability of the regulating agency to work with the project proponents to devise environmental protection and abatement measures which are satisfactory to both parties. On the proponent side, the principal incentive is to minimize cost, but at the same time be open to requests for environmental safeguards, to the extent these are required to obtain agreement on a contract for the development and production phases. On the government side a similar balance must be found, between a future government share in mineral rents, and the need to impose environmental conditions, which is politically acceptable.

This brings us to those parts of the contract which are related to the production phase itself. During this phase the two principal matters are mine safety/occupational health on the one hand, and environmental monitoring and compliance on the other.

Mine safety is a specialized branch of occupational health. However, much of it is related to highly specialized aspects of mining engineering and mine ventilation. The information base and knowledge needed to deal with these issues is not presently available in Greenland. Embarking on an effort to build an organization to deal with the area in Greenland would only be economically justified at a certain level of mining activity. Until such a level is reached, the strategy should be to place the inspection power with the usual agency monitoring occupational health in Greenland, and the use (and learn from) external mine safety consultants until the critical mass of mining activity has been reached.

For environmental monitoring and compliance, the lack of previous experience is less of a problem. As noted there exists an environmental agency for mining in Greenland and this agency has some experience regulating mines and monitoring abandoned mines. In practical terms, however, the development and production contract must provide for access to the mine site for monitoring purposes, and it must also require the operator to monitor emissions and effluents to determine whether they meet the targets agreed with the environmental agency.

An integral part of approving a development plan is that it must include a closure and rehabilitation plan. The chief objectives of such a plan are protection of public health and safety, minimization of environmental impact, and rehabilitating land for other uses. The underlying assumption for requiring such a plan is that it is the best way to internalize some, if not all, of the environmental effects of a mining operation. In the case of Greenland the problem facing a regulator is determining which impacts involve a loss, or risk of a loss, to society. This also means that the regulator must determine which impacts are acceptable because they do not involve a [significant] loss[72]

Recommendations on development approval and project operation

[1] Determine and announce general minimum environmental constraints before exploration proceeds;

[2] Provide incentives for exploration projects to collect environmental baseline data as part of exploration;

[3] Ensure that a current information base on environmental regulation and compliance costs exists;

[4] Include environmental conditions in the production license issued to the mining company which regulates the development, production and abandonment of the mine, the latter using a walk away or passive care design principle.

[5] Build a mine safety inspection organization gradually, in response to demand and using external consultants for inspection and training of inspectors.

CONCLUDING REMARKS AND THE FUTURE SHAPE OF REGULATIONS

The recommendations presented above all concern the content of a distinct mining policy for Greenland, and they are not designed to deal with the wider impacts of mining projects. Furthermore, none of the recommendations are made with petroleum in mind, since this aspect was de-emphasized as a result of the adverse conditions in off-shore areas. On the basis provided by these recommendations a new mining act can be created. Similarly, environmental protection

[72] In the case of Greenland an example of a loss is heavy metal pollution of inshore fish and animal species used as human food. On the other hand only limited loss may result from landscape disturbance in remote and uninhabited parts of North Greenland.

and policy organization can be addressed based on these recommendations. Modifications to the basic underlying political structure, which specifies joint management and the Greenlandic right of veto, are not involved: major decisions are still to be reached through agreement between Denmark and Greenland. It may, however, be necessary to define clearly the distinction between matters requiring political agreement and matters which can be settled by the (future) MRA.

9

THE IMPACT OF MINE DEVELOPMENT AND IMPLICATIONS FOR GREENLAND

Development of mines can have a number of different non-environmental impacts. These include direct and indirect economic effects, as well as employment, training, and other social effects. For a sparsely populated country such as Greenland these impacts must be thoroughly understood, and a set of management strategies developed in order to maximize the [potential] benefits associated with a mine development.

The present chapter is concerned with these impacts, and with the management strategy. The approach is initially based on three brief case studies, which highlight some of the effects of mine development, and the experiences of dealing with them. The cases are followed by a discussion of the emerging Canadian practice of using socio-economic agreements between resource companies, government, and local, primarily aboriginal, residents/communities. The third part of the chapter is based on these experiences, and the different points raised in chapter 3 concerning the effect and management of mineral rents. Following a digression on natural resource trust funds, the sections in this part contains a discussion of the relevant management strategies relevant to Greenland with respect to mineral revenues, employment and training, and the choice between mining camps and mining towns.

THE CASE STUDIES

The case studies describe three mines in the Arctic. One is Greenlandic (the Black Angel) which ceased operations in 1990. The other two are Canadian, and still operating (Polaris and Nanisivik). They were selected for their Arctic connection and the variation between them in terms of their location in relation to existing communities. The fact that they are all three zinc and lead producers is a coincidence.

The case studies are intended to show some aspects of the impacts of mining which occur locally, and which are frequently lumped together under the general heading of "socio-economic impacts". Using this heading, however, obscures the fact that a mine may have a number of distinct yet interrelated effects. The cases present a brief outline of impacts as they have been reported in various contexts. The issues accorded special attention in these cases are primarily employment and training, the choice between various forms of staff accommodation, and communication between local residents and communities, government agencies, and the mining firm.

Case study no. 1: Nanisivik Mines[73]

The Nanisivik lead-zinc mine is situated on the Northern end of Baffin Island, on the west side of Strathcona Sound, a fjord which extends south from Admiralty Inlet, and 27 km. east of the community of Arctic Bay. A production decision was made in 1974, and the mine came into production in 1976 as a joint venture between Mineral Resources International, Metallgesellschaft Canada, Billiton Minerals, and the Canadian Government. The latter became a partner in the project as part of an agreement reached in 1974, whereby the government would pro-

[73] This case relies primarily on the description in the first report on native participation in mining from the sub-committee of the intergovernmental working group on the mining industry (Sub-committee of the intergovernmental working group on the mining industry 1990) and on the extensive study by Wojciechowski (1982). Additional information has been provided by Doug Padget of the Canadian Government, Department of Indian and Northern Affairs and by Jim Marshall, project manager of Nanisivik Mines Ltd.

vide infrastructure (roads, airport, wharf facility, and town site) in return for an 18% equity share in the mine, and commitments by the mining company in a number of other areas:

- Establishment of a joint government/company/native monitoring committee to oversee the agreement;
- Two federal appointees on the Board of Directors of Nanisivik Mines Ltd.
- A target of 60% natives in the workforce by the third year of operations
- A commitment to introduce special training programs for natives

Perhaps the most important direct impact has been through employment. Table 9.1. shows how the employment at the mine has evolved since the second year of operations, 1977. The share of inuit[74] employees has remained constant in the 21-27% range, and it has never reached the 60% target set out in the 1974 agreement. One possible reason for this discrepancy, put forward in a report on native participation in mining, is the high (90% per year in 1988) turnover rate for inuit employees compared to the much lower rate for southern employees (30% in 1988) which, combined with the cost of training replacement inuit employees, precludes a higher level of inuit employment.

TABLE 9.1. EMPLOYMENT AT THE NANISIVIK MINE, NWT

Year	Total employees	Southern employees	Inuit employees
1977	215	164	51 (24%)
1978	213	163	50 (23%)
1979	207	158	49 (23%)
1980	203	156	47 (24%)
1981	199	152	47 (24%)
1982	193	148	45 (23%)
1983	183	139	44 (24%)
1984	183	139	48 (26%)
1985	180	131	49 (27%)
1986	181	132	49 (27%)
1987	176	128	48 (27%)
1988	175	131	44 (25%)
1989	190	142	48 (25%)
1990	n/a	n/a	(25%)
1991	n/a	n/a	n/a

Source: Personal communication from Mr. Doug Padget, Department of Indian and Northern Affairs, Hull, Quebec.

74 The term inuit is used in this case because no other aboriginal population group is employed by the mine.

Although the goal of 60% inuit employment at the mine was not reached, the mining company does not consider the high turnover rate among inuit unreasonable. Because many leave the mine during summer in order to hunt and fish, and then return for the rest of the year the average tenure of employees is 3.75 years[75]. The length of tenure and level of skills attained give a slightly fuller impression of the pattern. As of 1988 three inuit had more than 10 years of experience, and 29 had more than 5 years experience. When combined with the fact that in 1989, 6 of the 48 inuit were in skilled positions, and 12 were in semi-skilled positions (none were in management and the remainder worked as trainee labour) it appears likely that the inuit workforce is composed of a stable core with a long record of permanent or semipermanent employment, and a fringe of more transient unskilled inuit labour.

Although there are no data linking the level of skills and the length of employment it is likely that there is a positive link between the two. This raises the question of why the fraction of inuit employed has remained constant. If length of tenure leads to a higher level of skills then one would expect a gradual increase in inuit employment. The mining company is of the opinion that barriers keeping the inuit employment constant are not educational, but rather social and cultural (Sub-committee of the intergovernmental working group on the mining industry 1990). This view is amplified by Mr. Jim Marshall, who has been project manager for Nanisivik since mining began in 1976. He believes that some inuit employees are better qualified for their jobs than southern counterparts, but find it difficult to gain advancement in an organization dominated by southerners (Marshall, personal communication, 1991).

In a wider perspective it is important to note the origin of the inuit employees at Nanisivik. As noted, they are all inuit, and 80% come from the North Baffin Island region, and one third come from the community of Arctic Bay. The local economy is thus injected with around C$ 1 million annually in disposable income. Added benefits of the mine are lower social assis-

[75] It is not clear whether this average is for inuit only or for the total workforce.

tance payments, improved transportation, and the possibility of combining industrial employment with traditional lifestyles.

The evidence on disadvantages and problems associated with the Nanisivik Mine is expressed, among other places, in the investigation carried out by Margot Wojciechowski of Queens University (Wojciechowski 1982). The observations in this report can be separated into three distinct groups, (1) The role of, and relations to local communities; (2) Mine development planning and the role of government agencies; (3) Economic impacts expected and derived from the mine development. While these observations are now dated, they still carry important messages for future mining projects in the Arctic.

The role of, and relations to local communities. Based on the limited extent to which the community of Arctic Bay was consulted and generally kept informed about events related to the project, the need to involve affected communities is identified as a central element in policy design. The possible scope of such involvement is similarly important and ranges from direct influence on decisions over giving advice to being passively informed about decisions already made. The areas where the scope was unclear was in the case of relations between the mine and the community of Arctic Bay. The choice between building a town site at the mine or using a fly in/fly out approach[76], possible impact on the community when a town site was the choice, as well as general communication between the community and the mine were all seen by the community as important issues. Based on these experiences a number of very clear recommendations are given:

1. Affected communities should be identified as early as possible;

[76] The final decision to build a town site at Nanisivik was made against the wishes of the Community of Arctic Bay. The community preferred to have families housed at Arctic Bay and have single workers (primarily from farther away and from the south) housed in mining camp at Nanisivik. The indications are that the decision to construct the townsite occured at the instigation of the government. The company would have preferred a mining camp operation (Wojciechowski 1982).

2. Communications with communities should categorize possible impacts (social, economic or environmental);
3. Specific impacts identified should be subject of consultations;
4. The role of the community should be absolutely clear, such that the distinction between giving information, receiving information, giving advice, and having influence is made absolutely clear at the outset.

Mine development planning and the role of government agencies. The case of Nanisivik is peculiar in that the government of Canada was (primarily for strategic reasons) extensively involved in the project, both through a wide range of agencies (16 in all), and through the direct equity investment. The process leading from the original development proposal from the mining company to the conclusion of the development agreement lasted from 1970 to 1974, and was primarily concerned with three issues, employment of northerners, the export license needed to sell the mineral concentrate outside Canada, and the financial support for infrastructure given by the government[77].

Economic impact derived from mining. The two principal economic effects of the Nanisivik mine were expected to be employment (and training) of northern residents, and economic spin-offs for northerners. The hopes for considerable employment of northern residents, as was required in the Nanisivik Master agreement, had not been reached in 1981 when the first major study of the project was undertaken (Wojciechowski 1982). As shown in table 9.1. little improvement has been made in this area to date.

The so-called economic spin-off effects (i.e. secondary economic effects) have not materialized to any significant degree. A few local residents have set up businesses which service or supply the mine, but the long term effect is likely to be "....one or two prosperous families..." (Wojciechowski 1982).

[77] Strangely, the Polaris Mine, which was going through the approval process at the same time, was never offered similar support, despite the much greater potential of the orebody (Graham 1982) to support economic development over a longer period.

The development of mines in the North of Canada seems to have involved very great faith in the ability of mines to create lasting improvements. The case of Nanisivik indicates that such faith is greatly misplaced. It is clear (see chapter 3) that sustainable development (in a purely economic sense) requires a very high rate of capital accumulation based on mineral rents or the existence of a permanent renewable resource base. Neither of these seem to be present in the North Baffin region, and it is difficult to see why the expectations were so great. Indeed, it may even be argued that the limited opportunities for sustainable development based on the mine should have been emphasized much more clearly to the parties involved.

The experiences of inuit associated with the Arctic Bay-Nanisivik area have also been analyzed by Dahl (Dahl 1984), who compares this mine to the Black Angel mine at Maarmorilik in Greenland. Of the three main topics discussed (employment, environmental impact, and communications), the fact that the 60% goal for employment of inuit was never reached is noted as being particularly disappointing from a local inuit point of view. On the environmental impact the verdict is positive (low levels of pollution and negligible [observed] impact on hunting), while on communications the experience is a mixture of positives (improved transport links etc.) and negatives (disruption of ice hunting as ore ships break up the ice in the fjord system in the spring).

Case study no. 2: The Polaris mine, Little Cornwallis Island, NWT[78]

The second case study concerns the lead-zinc mine operated by Cominco Inc. on Little Cornwallis Island, NWT, 60 miles Northeast of Resolute Bay. The decision to develop the mine was made in late 1979, when, following protracted negotiations between the company and the Canadian government, a Letter of Agreement was signed by the parties. Construction began in January 1980, and production commenced in late 1981. A further agreement on employment

78 This section is based on Graham (1982) and personal communications from Doug Padget of DIAND and Jim Armstrong of Cominco Inc.

and training was included in a "Memorandum of understanding" signed by the company and the Government of the North West Territories in August 1981.

Specific information on the provisions of the Memorandum are not available, but it is clear that it did not provide for any formal target or quota for inuit employment at Polaris. One reason for this may have been the experiences gained at Nanisivik. Compared to Nanisivik the data on employment are much more limited. Table 9.2 has been compiled from personal communications with officials of the Canadian government and the mining company, and is partly based on annual reports of the company.

TABLE 9.2. INUIT EMPLOYMENT, POLARIS MINE, LITTLE CORNWALLIS ISLAND, NWT

Year	Total employees	Northern employees	Inuit employees
1984	272	75	25 (9%)
1985	264	28	16 (6%)
1986	263	56	28 (9%)
1987	261	35	(~10%)
1988	263	20	(~10%)
1989	267	n/a	(~10%)
1990	274	n/a	(~10%)
1991	246	n/a	(~10%)
1992	239	n/a	(~10%)
1993	n/a	n/a	14[a]

Note: a. In 1993 14 inuit were employees, 9 of these in permanent positions

The early examination of the prolonged process leading to development of the Polaris mine (Graham 1982) identifies a number of distinct problems, which are in many ways similar to those reported from Nanisivik. The major issue identified in the 1982 study is not one of employment (or the lack of it), but rather the process under which development approval was given. The role of local communities in the process is described as extremely confused, particularly with respect to the distinction between communities being informed, consulted, and participating in the process.

Other important issues identified in relation to Polaris include the limited capacity of local communities to understand and deal with complex issues related to mine projects, especially if the limited leadership resources of the community are preoccupied with more pressing prob-

lems. Further, the study identified a much larger commitment to work with local communities on the part of the company than on the part of involved government departments.

Case study no. 3: The Black Angel Mine, Greenland

The Black Angel lead-zinc mine which operated from 1974 to 1990 was situated across the fjord from the abandoned settlement of Maarmorilik, some 50 km. Northeast of Ummanaq on the West coast of Greenland. The mine was developed by Greenex A/S, which was majority owned by Cominco Inc. through a subsidiary. In contrast to the Nanisivik Agreement no special emphasis was placed on employing and training Greenlandic labour. The closest to an agreement on this issue is section 15 of the mining concession for the mine. This section specifies that the concessionaire must employ Danish labour to the greatest extent possible.

Apart from the tax revenues which accrued to the governments of Denmark and Greenland, the primary [non-environmental] impact of the mine has been through employment of Greenlandic labour. The information on this is quite extensive because the mine had to submit a report to the government on the size, composition and compensation of the staff employed in Greenland. The employment data are summarized in table 9.3, which also includes a number of observations on the level of staff turnover. The remarkable jump in employment of Greenlanders from 1979 to 1980 has been linked to the introduction of Home Rule in Greenland and a modification of the tax system which meant that Danish labour no longer had to remain at the mine for two full years in order to obtain special tax advantages (Dahl 1984).

The better employment results (relative to Nanisivik and Polaris) shown in table 9.3 have been qualified slightly by a former senior executive of Cominco Inc., who was close to the operation during the early 1980's. "Payrolls were padded", meaning that more people (i.e. Greenlanders) were employed than was strictly necessary (Poul Hansen, personal communication, 1991). Whether this situation persisted throughout the life of the mine is difficult to determine, but it is clear the number of staff, and the number of Greenlandic employees, declined after 1984/85,

when the mine almost closed. Instead, the mine was taken over by the Swedish company Boliden AB. The origin of Greenlandic employees was also indicated in some of the Greenex Annual reports. In 1984, almost half of these came from the municipality of Uummannaq, while another 32% came from the adjacent Disko Bay area. This reflects the employment policy of the company (Dahl and Lyberth 1980).

TABLE 9.3. EMPLOYMENT AT THE BLACK ANGEL MINE, GREENLAND

Year	Total employment	Greenlandic employment (%)	Employee turnover
1974	311	11	n/a
1975	339	13	50%
1976	344	15	38%
1977	324	17	57%
1978	295	15	48%
1979	297	18	49%
1980	319	33	44%
1981	336	41	41%
1982	349	42	34%
1983	333	44	<40%
1984	340	43	n/a
1985	342	35	n/a
1986	271[a]	32[b]	n/a
1987	256	23	n/a
1988	227	22	50%
1989	214	21	33%
1990	195	n/a	n/a
1991	8	n/a	n/a

Notes:
a. The sharp drop is related to the sale of the mine to the Swedish mining group Boliden
b. Training of new miners etc. ceased due to the short remaining mine life.
Sources: Greenex annual reports

Information on the level of skills acquired by Greenlandic labour at Maarmorilik is not as complete. Data from the period 1980-84 published in the annual reports of the company (see table 9.4) indicate that the growth occurred primarily in the unskilled category. Nevertheless it is clear that the fraction of skilled workers is much higher than in Nanisivik.

TABLE 9.4. GREENLANDIC EMPLOYMENT AT MAARMORILIK ACCORDING TO SKILL LEVEL

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Skilled labour	7%	7%	8%	11%	8%	15%	16%	20%	16%	20%	17%
Clerical workers	4%	5%	7%	9%	10%	14%	16%	20%	21%	21%	23%
Unskilled labour	18%	19%	20%	27%	25%	26%	61%	74%	75%	83%	83%

Source: Greenex A/S, Annual Reports

It is clear that mining operations have external effects. In the case of Marmorilik, two important effects were heavy metal contamination of some marine life in the fjord system near Marmorilik and the disruption of the hunting environment by the spring arrival of ore carriers. The first problem was addressed incrementally by stricter regulations of talings discharge, while the second problem was reduced through negotiations after local hunters had blocaded the first ore-carrier one year.

TABLE 9.5. ECONOMIC IMPACT OF MINING ON THE MUNICIPALITY OF UUMMANNAQ (MILLIONS DKR)

Year	Payroll	Income tax revenue	Municipal tax %	HR tax %	Uummannaq	Total revenues to Uummannaq	
1975	n/a	4.592	15	0	4.592	6535	70%
1976	n/a	5.637	15	0	5.637	7636	74%
1977	48.653	5.802	15	0	5.802	8736	66%
1978	48.109	6.039	15	0	6.039	10700	56%
1979	54.053	7.563	15	2	6.673	13390	50%
1980	63.154	9.068	16	2	8.060	15640	52%
1981	67.455	10.259	16	3	8.639	19250	45%
1982	77.733	14.271	20	3	12.410	26643	47%
1983	81.850	15.251	20	3	13.262	27936	47%
1984	91.070	17.955	20	4	14.963	34030	44%
1985	100.034	20.151	20	4	16.793	37249	45%
1986	80.357	19.221	21	6	14.950	40052	37%
1987	85.292	24.392	23	10	17.000	49753	34%
1988	74.722	28.533	24	13	18.508	68708	27%
1989	97.799	33.773	25	13	22.219	73307	30%
1990	n/a	26.058	25	13	17.143	68146	25%

Sources: Grønland yearbooks and MRA 1991a

A study carried out by the Institute for Eskimology at University of Copenhagen indicates that internal problems were considerable. The study by Dahl and Lyberth (1980)

reveal a number of problems at the mine, including pay-discrimination (abolished in 1977), other forms of discrimination between Greenlandic workers and Danish supervisors, differences in life-style and food preferences, as well as the isolated mining camp nature of the operation.

The economic impact of this mine involves both the municipal and national level. For the minicipality of Uummannaq, the mine has provided very significant wealth. Table 9.5 uses the data on personal income tax revenues, tax rates and total revenues to indicate the importance of Marmorilik related revenues.

TABLE 9.6. ECONOMIC IMPACT OF THE MARMORILIK MINE ON HOME RULE FINANCES (MILLIONS DKR)

Year	Payroll	Income tax revenue	Municipal tax %	H.R. tax %	H.R Treasury	Mineral Revenue	Total Home Rule revenue
1975	n/a	4.592	15	0	0.000		0.000
1976	n/a	5.637	15	0	0.000		0.000
1977	48.653	5.802	15	0	0.000		0.000
1978	48.109	6.039	15	0	0.000		0.000
1979	54.053	7.563	15	2	0.890		0.890
1980	63.154	9.068	16	2	1.008		1.008
1981	67.455	10.259	16	3	1.620		1.620
1982	77.733	14.271	20	3	1.861		1.861
1983	81.850	15.251	20	3	1.989		1.989
1984	91.070	17.955	20	4	2.993		2.993
1985	100.034	20.151	20	4	3.359		3.359
1986	80.357	19.221	21	6	4.271		4.271
1987	85.292	24.392	23	10	7.392		7.392
1988	74.722	28.533	24	13	10.025	28.822	38.847
1989	97.799	33.773	25	13	11.554	77.954	89.508
1990	n/a	26.058	25	13	8.915	48.949	57.864

Source: Greenex Annual reports, Greenland yearbook and MRA 1991a.

Although declining over the period the loss of the mine in 1990 removed 25% of income tax revenues. The declining share of Marmorilik's contribution to the municipal coffers in the latter years of the operation also reflects the decline in total number of employees. The importance of the payroll to the local community is more difficult to determine. As noted, a majority of the employees were from the area near the mine and their salaries will have

benefitted the local economy. However, in the latter years of the mining operation the fraction of local employees declined and with them the local benefits from salaries.

The mine also had some impact on the Home Rule finances, albeit on a smaller scale in relative terms. The data presented in table 9.6 shows that income taxes provided some revenues but it also shows that only when revenue sharing was agreen on in 1988 did revenues to the Home Rule treasury become significant.

Discussion of case evidence

The cases presented in this section point to a number of key problem areas in relation to mineral projects in the Arctic. The first of these is the economic impact of mines. Apart from the general importance of accumulating social capital, it seems clear that the major element in benefits to northern communities is through wage payments. In contrast, the emphasis on development of the so-called spin-off benefits, seems misplaced. The reason is that such spin-offs (local service industries) are heavily dependent on the existence of a productive industry, without which they cannot exist. In this respect the absence of a resource base, which can support spin-off activities over long periods, means that the emphasis on them was not only misplaced but may have been directly wasteful.

When employment is the chief source of mining benefits to local communities the extent to which local residents are employed becomes highly important. In this area the evidence is mixed. On the one hand the quotas specifying 60% inuit employees at Nanisivik did not work while on the other hand the absence of similar quotas at Polaris led to an even worse result. The impression from the Black Angel mine is that a considerably higher degree of success in this area was achieved without great effort. One possible explanation for the difference may be that Greenland has a greater and more concentrated pool of labour for which wage-earning employment is not a strange new concept. The three orebodies are comparable in the sense that they employed the same general mining methods (room and pillar, cut and fill) and thus the nature of the orebodies cannot account for the observed differences.

The second problem is the role of local communities. Both at Nanisivik and at Polaris considerable difficulties in the communication between the company, government, and the communities were reported. These problems were both related to the role of the community in the process leading to approval of development plans, and the extent to which impact on the community were taken into account during the approval process. One of the key problems which can be identified here, is the difficulty of ranking communities surrounding the mine in relation to how impacts are assessed and how communities are informed, consulted or have influence in relation to the approval process.

The third problem is more practical. Any mining development has to choose between building a town site near the mine, or using a system of worker rotation, with only a bunkhouse on site. One factor influencing this decision is the expected life of the mine, a long life favours a town site. The Nanisivik case indicates, however, that governments may have a large impact on the decision and that they are not necessarily concerned with questions of economic efficiency[79]. The choice of a town site would only seem reasonable if there is a chance that the town has a future after the closure of the mine it is to service.

SOCIO-ECONOMIC AGREEMENTS FOR MINING PROJECTS

One of the distinct conclusions to emerge from the case studies above was the inability of the Nanisivik agreement to reach the goal of 60% inuit employment, and the relatively greater success in creating inuit employment at Maarmorilik. This suggest a closer examination of the concept of "socio-economic agreements" which has been used extensively in Canada.

The next section looks at the content of these agreements, and is based on the work of the "Sub-committee of the intergovernmental working group on the mineral industry". The

79 In the report on Nanisivik (Wojciechowski 1982) it almost seems as if government agencies were more interested in the technological aspects of developing a town from scratch in an extreme environment than in the wellbeing of local communities.

elements of the agreements are analyzed in the following section, and then the implications for Greenland are discussed.

Content of socio-economic agreements

The components making up the socio-economic agreements are listed below in point form. First, however, it should be noted that the intent of these agreements is "....to develop a frame-work that will facilitate efficient and effective use of resources by Canada, the province, the company, and local residents in an effort to achieve a mutually beneficial social and economic benefits agreement." (Sub-committee of the intergovernmental working group on the mining industry 1991). The individual components are as follows:

1. Recruitment policies of the mining company,
   - Give priority to local residents (e.g. inuit);
   - Minimum (and maximum) target level for local/northern employees.

2. Establishment of training programs, taking into account,
   - Apprenticeships and other training before and during operations;
   - Study programs at established schools;
   - General usefulness and relevancy of training for employment after mining ends;
   - Accommodation of training inside an existing vocational qualification structure.

3. Form a committee of company, government and local representatives with the task of,
   - Monitoring the agreement;
   - Ensure local residents are given priority in hiring;
   - Devise training programs;
   - Obtain subsidies from public funds to help implement agreement.

4. Employment by the mining company of an "Aboriginal Employment Coordinator",
   - Intended to take care of special programs aimed at local residents/labour;
   - Liaison to senior management;

5. Subsidize relocation and transportation,
   - Company can provide assistance to relocate aboriginals with families if possible;

- The company can similarly subsidize travel for aboriginal employees.

6. Work rotation,
   - Mining company can adapt work rotations to accommodate traditional lifestyles;
   - Rotation fly-in/fly-out operations devised to minimize impact of family separation.

7. Discrimination and discipline,
   - The company can introduce disciplinary rules to reduce or eliminate discrimination against aboriginal employees.

8. Youth awareness and scholarships,
   - The company can sponsor pre-employment activities for young aboriginals;
   - The company can support post-secondary education of children of aboriginal employees.

9. Counseling and language training,
   -A special counseling service (in addition to the employment coordinator (?)) can be provided to employees.
   - To facilitate work the company can provide [technical] language training and possibly bilingual signs.

10. Cross-cultural training,
    - Company can sponsor training of all employees such that the special character, culture and life-style of local employees is understood and respected.

11. Traditional economic activities,
    - Employment and work schedules can be organized to accommodate traditional activities;
    - The company can sponsor assessments of mine impact on the environment for traditional activities (i.e. hunting and fishing);
    - Company can compensate individuals or the local community for loss of income from traditional activities which are lost as a result of the mining development.

12. Business opportunities,
    - Company can develop programs to optimize local participation in economic activity generated locally as a result of mining;
    - Company can give priority to local suppliers if they are competitive;

- Company can provide information on its needs to potential local suppliers and organizations;
- Company can inform on tendering, bypass it, or award local suppliers special privileges in the bidding process.

13. Committee on economic and business development,
- The company could create a committee of stakeholders (itself, local residents, union, government) to oversee management of business opportunities.

14. Special subsidies,
- Fragmentation of large supply contracts to allow local suppliers to participate in the supply of the mine;
- Company can provide financial aid to viable local business projects;
- Company can issue letters of intent which may help local business developers to obtain financing.

15. Committee on community support,
- A committee organized by the mining firm can provide (financial) support for social, cultural, and community activities.

16. Communication and information,
- Can be provided through newsletters, briefing of local representatives, and use of local language.

17. Environmental management:,
- Company can use orientation and awareness campaigns to emphasize the importance of environmental responsibility;
- Protection of historical sites;
- Adopt a consultation process on resource use
- Comply with environmental regulations;
- Recognize impact of mining.

Special treatment and economic efficiency

The 17 main components of socio-economic agreements listed above raise both general and specific issues. The general problem associated with these agreements is that they involve extensive indirect as well as direct subsidies to a narrowly defined group of people (local residents/local aboriginal groups). The cost of these additional requirements must, however, be funded from income derived from the orebody. And if the funds needed to finance a socio-economic agreement are not available as payment to the resource owner, the total amount of rent is reduced - and no taxes can be charged on this amount. Thus, it may be argued that a socio-economic agreement is in fact a hidden tax.

In a fashion similar to the cost of environmental compliance and the use of royalties as a tax instrument (Poulin and Sinding 1993a), any other activity incurring an additional cost means that the mine has to obtain a greater net value from each unit of ore it mines. The result is clear, higher cut-off grade, more mineralized material left in the ground (which would have been ore if costs were lower), more rapid exhaustion of the deposit, and shorter periods with employment opportunities for local residents. In this context it would be highly instructive to investigate the financial performance of companies with socio-economic agreements and compare it to the success of the agreement and the nature of the ore-body.

In addition to this general critique, it should be noted that some elements of agreements are eminently sensible, while other elements are ambiguous or unclear. Sill others may not be necessary.

The elements associated with preferential employment (points 1,3,4,5,6,9)[80] implies discrimination in favour of local aboriginal labour and against alternative (southern) labour. On the one hand this type of policy may be considered necessary to achieve minimum employment targets. On the other hand, such discrimination can contribute to widen the cultural gulf between the two groups.

[80] Numbers in brackets refer to the 17 point list above.

With respect to training (2) the various objectives are most amiable in any context. The record from Nanisivik on this issue also indicates that inuit employees have obtained a variety of skills useful also outside the mining environment (Sub-committee of the intergovernmental working group on the mining industry 1990).

The inclusion of discipline, and penalties for discriminating against aboriginal employees (7) does not seem appropriate. It is difficult to imagine that rules (in a worst case with attendant complaints, hearings, and appeal procedures) can or will influence the basic attitudes of people. It is also hard to imagine why such rules should be one-sided. To the extent that cultural differences and intolerance are problems, the better approach is "cross-cultural training" (10) aimed at improving understanding and tolerance. It is important to note, however, that such tolerance may be undermined if pay, training opportunities (2,9), benefit package (including more flexible work rotation systems and travel subsidies), etc. differs among groups of employees. This also applies if an aboriginal group as a whole is favoured through subsidies and other forms of special treatment.

Implications for Greenland

The use of socio-economic agreements must largely be rejected, both in general and in the case of Greenland. The disadvantages are primarily associated with the cost of special treatment, which may include both a hidden tax[81], distortions of productive efficiency and inefficient resource use. In addition the use of positive discrimination in favour of one group will, in relative terms, discriminate negatively against other group(s).

The alternative is to signal clearly, to investors as well as labour groups (in Greenland), that employment of local labour is favoured, but only if it can take place on competitive terms. To a considerable degree, it is the Greenland Home Rule Authority's task to provide residents of Greenland with the prerequisites for competing. This will not only have to be done by

81 If redistribution to a specific group is the purpose then it would be better to tax the mineral rent and then pay whatever group a direct subsidy.

providing training opportunities at a mine, but, more importantly, by providing a good basic education, and supplementary training in a range of basic skills.

MANAGEMENT STRATEGIES FOR MINING DEVELOPMENTS IN GREENLAND

Management strategies for mineral developments in Greenland include three principal areas, all of which depart from the narrow and specific mineral policy issues discussed in the previous chapters. The three areas are management of economic impacts from mineral projects, management and optimization of employment and training aspects of mineral development, and management of economic spin-offs and location problems of mining communities.

Economic management, trust funds, and half of the mineral revenues from Greenland

The issues raised in chapter 3 were the wider economic effects of mineral projects. In the short and medium term the most important factors determining such impacts were the employment of local labour and the release of mineral rents into the economy. The impacts differ across sectors, depending on the structure of the economy, and it is clear that some of the resource movement effects discussed in chapter 3, in relation to the "Dutch Disease", can be experienced if a future mine in Greenland offers above normal wages. This would also be an argument against some of the special advantages aboriginal employees would have under a socio-economic agreement. If such agreements are used, the yardstick against which they should be measured, at least in the case of Greenland, is wages, work conditions, and training benefits offered in other industries in the country. The principal area of concern, however, is the effects of rents on the economy.

The basic ways in which rents can be introduced into the economy are transfers to individuals, higher government spending, increased government investment in physical assets, and through dividend payments from a permanent trust fund. The three former of these alternatives involve immediate outflows with the potential for problems of the type discussed in chapter 3. The remaining possibility is to create some form of trust fund. The rest of this section will ex-

amine this possibility in greater detail based on the experiences from two widely different trust funds, those of Alaska and Alberta. Based on the experiences with these, a trust fund model adapted to the special case of Greenland will be proposed.

The Alaska Permanent Fund (APF) was established in 1976 by an amendment to the Alaska Constitution which specified that ,

> *".....at least twenty-five percent of all mineral lease rentals, royalties, royalty sale proceeds, federal mineral revenue sharing payments and bonuses received by the State shall be placed in a permanent fund....."*[82]

The principal of the APF can only be used for eligible income producing investments such that the savings in the fund are protected from loss of value, and such that the principal will produce income in perpetuity (O'Brien and Olson 1990). Three goals were formulated when the fund was established:

1. Accumulation of a principal sufficient to assist the diversification of Alaska's economy;
2. Smooth the flow of government revenues when contributions from natural resource extraction start to decline;
3. To constrain government spending by placing the principal outside the reach of politicians.

The investment policies of the fund are conservative, emphasizing low risk and a diversified portfolio. Total assets have grown from $4 million in 1977, the first year of operation, to more than $13 billion in mid-1992. The net income in 1991-92 was US$ 1.035 billion (Alaska Permanent Fund 1992). Income to the fund derives from three sources, constitutionally required deposits[83], special legislative appropriations, and earnings from investments of the capital. The lat-

82 Amendment to the Alaska Constitution, Article IX, section 15.

83 The 25% which must ber saved does not apply to severance taxes (an important part of US mineral taxation) which means that only 10% of total revenues must be saved according to the constitution (Smith 1991). However, the state has made additional appropriations resulting in the fund having by 1988 received around 21% of total mineral revenues (O'Brien and Olson 1990)

ter must in any case partly flow into the fund as the rules for investment require that an amount, sufficient to offset the effect of inflation on the permanent fund, be ploughed back into the fund (Robinson and others 1989). The final major element in the structure of the APF is the dividend payment program. This began in 1982 and was based on the idea that Alaskans should be treated as shareholders in a corporation (O'Brien and Olson 1990). Under this arrangement half of 21% of the net income over the past 5 years is paid as dividends to all Alaskans, the remainder of earnings being placed in an earnings reserve account. The structure is indicated in figure 9.1 below.

One of the arguments for introducing the dividend payments from the APF was that the removal of the state personal income tax in 1980 required a new link through which the average citizen of Alaska had an incentive to keep track of state expenditures. The argument was essentially that by restraining state expenditures a greater amount of funds could be allocated to the APF for the long-term benefit of Alaska residents. O'Brien and Olson (1990) argue that the dividend program resulted in a lesser degree of fiscal illusion[84].

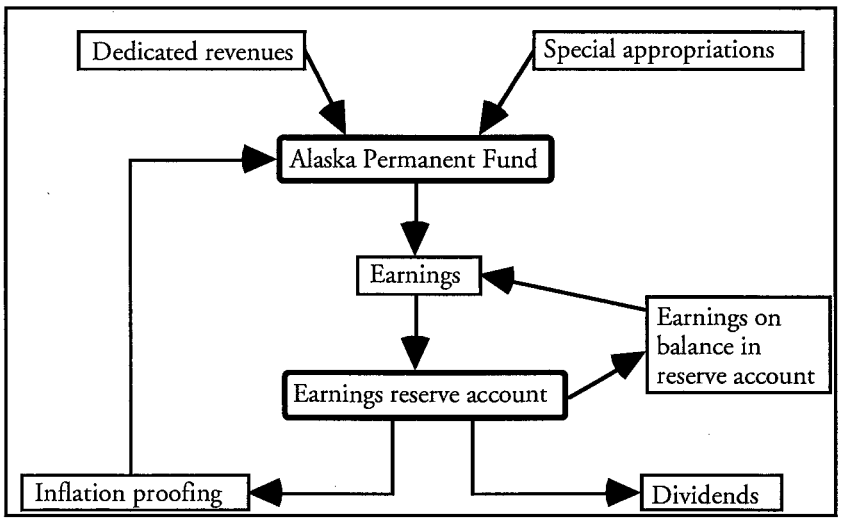

Figure 9.1. Organization of the Alaska Permanent Fund (modified from Robinson et. al, 1989).

[84] Fiscal illusion refers to the tendency of people to underestimate the true cost of government when the payment structures are complex and indirect, and they therefore tend to support higher public expenditures (Buchanan and Wagner 1977)

Two other impacts of the APF are identified by O'Brien and Olson (1990). The first is the effect of dividend payments on employment in the state. Based on simulations the dividend program is estimated to have created at least 8,500 new jobs in the state by 1990, equal to around 3.8% of total employment. The second impact of dividends is that they act to counter-balance the booms and busts of a natural resource based economy, although this was not the intent of the program. The data on personal income before and after dividend payments suggest that the expansionary phase of the business cycle is exacerbated while the contractionary phase is mitigated (O'Brien and Olson 1990).

The Alberta Heritage Savings Trust Fund (AHSTF) was created at the same time as the APF but, in contrast to the APF, by ordinary provincial legislation. The "Alberta Heritage Savings Trust Fund Act" stipulated that 30% of annual non-renewable resource revenues should be transferred to the fund, subject to annual authorization from the Alberta legislature. In line with Canadian parliamentary tradition, the authority to invest and manage the money in the fund was given to the provincial cabinet (Smith 1991). Following the debate which preceded the creation of the AHSTF, Smith (1991) distinguishes four separate objectives of the fund:

1. To serve as a savings account to provide a future source of revenue to offset declines in mineral resource revenues;
2. To reduce the provincial borrowing requirements and thereby reduce the Alberta's debt load;
3. To improve the quality of life in the province;
4. To strengthen and diversify the economy.

The data presented by Smith (1991) indicate that the second of these objectives came to dominate. Of the other objectives, some savings have been accumulated, but these are less than half the total which could have been achieved. Likewise, the quality of life has been improved by the investment in various "deemed assets", which include health and education projects, parks, and a golf course. The importance of the second objective is not only indicated by the type of

investments under the second objective, but also by the diversion of income from investments to the governments general fund. The investments under objective 2 are placed in the "Alberta Investments Division", and include debentures and bonds of provincial Crown corporations such as the Alberta Mortgage and Housing Corporation (Pretes 1988). A considerable part of the funds invested under the fourth objective is found in the "Capital Projects Division", and includes research facilities, grain hopper railway cars, and agricultural installations. The Capital projects division can account for up to 25% of the fund principal, and are not intended to yield a return (Smith 1991). The exception is the development of a medical industry in Alberta, which is partly the result of AHSTF investments in research. The four objectives can then be said to have been partly achieved, although the criteria for selecting beneficiaries is not clearly defined. In addition, the investments, particularly under the second objective, are concentrated on short- and medium-term benefits.

The fund received the 30% of resource revenues from 1976 to 1983. From 1982 lower oil prices and recession led the government to reduce the payments to 15% from 1983, and eliminate them completely by 1987. In addition, the inflation protection had been eliminated in 1983 so that all investment income was used for government spending (Smith 1991).

The ill health of the AHSTF is perhaps better understood by considering the flows in and out of the fund since 1976. The inflow consists of the share in taxes (C$13.3 bn. by 1990), and investment income (C$ 12.5 bn.), which total C$25.8 billion. On the outflow side there are both budget spending (C$10.9 bn.) and adjustments to the value of a range of "deemed assets", and other uncertain investments (non-marketable assets: C$3 bn., government debt, C$1.3 bn., farm mortgages, C$0.5 bn., and low cost housing assets, C$1 bn.) makes a total of C$16.7 billion, leaving the current asset base in 1991 at around 9.3 billion. If the lack of inflation adjustment since 1983 is also taken into account, the value of the fund principal is even smaller (Mumey and Osterman 1990). The latest information on the Alberta Heritage Trust

shows that total assets were C$12.04 billion, with "deemed assets" accounting for C$3.28 billion (Alberta Heritage Savings Trust Fund 1992).

The wide gap in terms of results between the two trust funds examined here is founded on several circumstances. The fact that the Alaska Permanent Fund is protected by the constitution has played an important role in keeping attempts to spend the fund money for short-term political purposes at bay, although several attempts have been made (O'Brien and Olson 1990). In contrast, the Alberta fund is not as well protected, the problem being both the control, the legislature of Alberta has over payments to the fund principal, and the discretion the Alberta cabinet has in deciding how the fund is invested. The fund's vulnerability to political interference may also have been compounded by the hostility with which Alberta generally views the "establishment" of Eastern Canada (Pretes 1988). One other feature of the Alaska Permanent Fund which may have protected it against the greedy fingers of politicians is the dividend program which has made the fund more visible to the average citizen of Alaska. Perhaps the most succinct statement of the difference between the Alberta and Alaska funds is the following, taken from Terence Corcoran, economic columnist of the Toronto *Globe and Mail*:

"Alaska has a heritage fund. Albertans have a slush fund for the politicians"[85]

Apart from the fact that savings in both cases have been only a fraction of total revenues from mineral resources, the description above raises an important issue. This is related to the purpose some trust funds are expected to serve. In analyzing the options facing various native groups in Northern Canada, if and when native claims settlements are settled between them and the Government of Canada, the use of trust funds to secure local development (referred to as "trust based development" below) has been advocated extensively (Pretes 1990; Pretes and Robinson 1989; Robinson and others 1989). The idea is that by investing and inflation-proofing the payments associated with settlements, "harvesting" [excess] interest income will enable the creation of a

85 The Globe and Mail, Toronto, May 7th, 1991, p. B2.

number of benefits to northern residents. These can take various forms, ranging from scholarships over grants/loans to small-business entrepreneurs to support for hunters who wish to remain on the land.

The payments of this kind advocated by Robinson and co-workers must be seen as an alternative to direct dividend payments to each resident (in the case of claims settlements to each member of a "first" nation covered by the settlement) as they occur in the Alaska Permanent Fund model[86]. However, the uses of trust dividends proposed in the trust development model will involve differential distributions, such that those in need will be supported while others will not. By embarking on redistribution of wealth through a trust fund, the fund enters one of the most difficult areas of politics, and it may be argued that such redistribution is best left to the elected politicians, who shape the tax and transfer payment systems. Another problem of trust based development is that in cases involving support to businesses out of trust dividends, there will be a source of capital which is less expensive than capital obtained on the open capital market. This means that the assumption underlying the business support program (separately or in combination) is that the businesses will be uneconomic, and therefore need support, that the risk involved is so high that capital is made prohibitively expensive to the entrepreneur, or that capital markets are not functioning properly, denying Northern entrepreneurs access to capital.

When subsidized capital, or direct subsidies, are needed it is important to look closely at the reasons why this is the case, and on the possible solutions. On the one hand projects and business ideas may need support if they are not viable, for example if their market or resource base is too narrow. These are fundamental flaws, which indicate a constant or recurring need for subsidies. On the other hand there are projects based on sound ideas, but which are unable to attract the required financing because lenders are generally unwilling to operate in the North. If an ill-functioning capital market in Northern regions is to blame, then there may be a need for establishing local banks, under local control, but the argument that trust money should be used

86 The native claims settlement in Alaska also created a number of trusts or corporations for natives. However, their financial performance has been greatly disappointing (Pretes and Robinson 1989)

is not clear. If local control is needed to provide the banking and other financial services then such institutions should be created, but only on normal commercial terms, and only with trust money as part of a diversified portfolio strategy for the trust fund.

With these qualifications in mind, it is clear that the trust fund model used in Alaska is much preferable to the "development" oriented approach used in Alberta, as well as to most combinations in between. In choosing a fund model it is important to note not only that the trust fund/development distinction is important, but also that the "owners" (the residents) of a proposed fund should have a possibility of expressing their preferences. Such an opportunity was given to the residents of Alaska (Pretes 1988), while in Alberta the decision to create the AHSTF followed an electoral victory of the incumbent Premier of the day, Peter Lougheed, who "interpreted" the election result to mean that the people wanted a fund (Smith 1991).

The purpose of the preceding discussion of trust funds is to propose such a fund for Greenland. As noted both above in chapter 7 and elsewhere (Foigel 1980), one of the most problematic elements in the relationship between the Northern and Southern parts of the Danish realm is the question of subsurface ownership. While the subject is traditionally dealt with in terms of constitutional law (Harhoff 1993), the issue is strongly influenced by the question of control over mineral revenues.

One possible way to reduce the existing conflict over "ownership" of the resources or "sub-surface" of Greenland is to separate the discussion into two [partially related] issues. One is economic, and concerns the benefits derived from the stock of non-renewable resources located in Greenland, while the other is legal, and constitutional, and concerns the status of the sub-surface and control over it. Because these issues have hitherto been considered together it has been difficult to arrive at a solution for the control over, and location of the Mineral Resources Administration, and therefore also to achieve the thorough review and reform of the complete mineral policy, as advocated in chapter 8.

The specific instrument which will allow the separation of economic and legal issues is the creation of a trust fund which is based on the structure of the Alaska Permanent Fund, with

two possible recipients for the dividends from the fund[87]. The principal of the fund would come from future revenues accruing to Denmark as part of the revenue sharing agreement[88], and the dividends could either be used to reduce the transfer payments, or for direct payment to the residents in Greenland. The structure of the proposed fund is illustrated in figure 9.2.

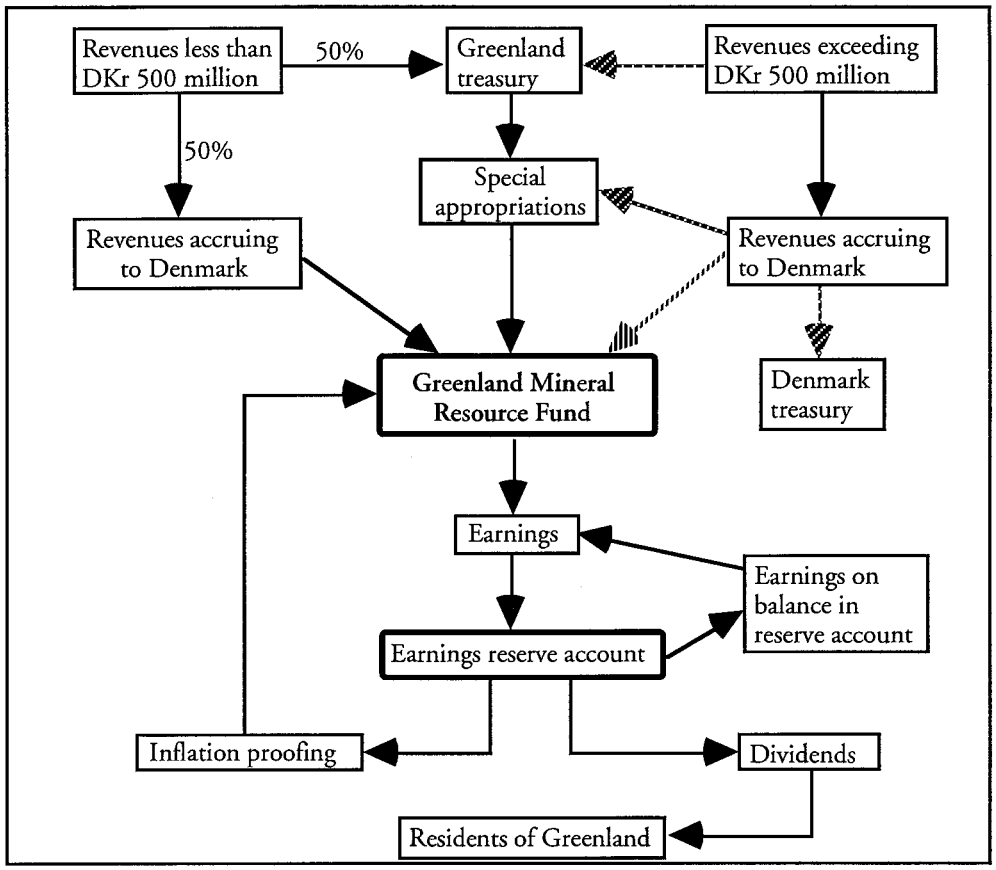

Figure 9.2. The structure of the proposed Greenland Mineral Resource Trust Fund. Cross hatched arrows indicate alternative payment flows. (Source: developed from Poole and others (1992))

The experiences from Alaska and Alberta indicate that substantial revenues are needed. Given the emphasis we have placed on metallic and other non-energy resources, which commonly in-

87 A provisional name for the fund could be the "Greenland Mineral Resource Fund". The model presented here is an extension of a previous model developed by Poole, Pretes, and Sinding (1992).

88 It is important to note that if Denmark insists that revenues in excess of DKr 500 million accruing to Greenland are deducted from net unrequited transfers then Greenland this will have an incentive to spread out mining operations over a period sufficiently long to bring annual revenues below DKr 500 million.

volve lesser quantities of resource revenues, the concept of a trust fund may seem irrelevant to Greenland. However, the fact that a fund may serve to reduce fiscal illusion, and generally create a better understanding of mineral industry may alone be sufficient justification. In addition there is also the possibility that a fund can accumulate sufficient capital to generate perceptible benefits to each Greenlander. To illustrate this point a very simple numerical example has been constructed (see table 9.7).

We examine a situation with three mineral deposits being discovered and developed in Greenland. Each mine yields a constant level of revenues (DKr 50 million annually for 10 years) but the revenue stream is offset by 5 years for each mine, giving a total revenue payment period of 20 years. For simplicity prices are assumed constant, the real rate of interest is set at 3%, and the population of entitled residents is 40,000. The model also takes into account that the trust fund will receive half of the total revenues. On the other hand, the example involves some ridiculously small dividends in the early years of the trust fund. If dividends were instead accumulated for the first 10 years, slightly higher dividends would result afterwards. The main impression of a fund able to pay out the modest sum of some 5-1,000 DKr remains.

The data presented in table 9.7 show two important things. The first is the limited constant benefits to Greenlanders if only small and medium-size mines are developed. The second is that despite revenues much more modest than those of the Alaska and Alberta funds, a reasonable level of dividends (provisionally defined as individual annual payments in the range DKr 3,000-5,000 (C$ 600-1,000) are not unimaginable as a result of the much smaller population in Greenland.

An interesting fact emerges if the revenues used in the model are all multiplied by ten, corresponding to annual revenues from each mine of DKr 250 million. Under the existing revenue-sharing agreement, years 6 to 15 would generate excess revenues, over which Greenland and Denmark would have to negotiate. Given the pre-1988 policy of using mineral revenues to finance the net unrequited transfers it is very probable that the Danish government will insist on

appropriating the major part of these revenues. This means that within the model it is in Greenland's interest to shift, if it has control over resource management, the development of mines nos. 2 and 3 forward by 10 years, respectively, in order to maximize the revenues to Greenland. As discussed in chapter 3, such delays are likely to be inefficient.

TABLE 9.7. NUMERICAL EXAMPLE OF A TRUST FUND BASED ON 3 MINES

Year	Mine no. 1	Mine no. 2	Mine no. 3	Total fund revenue	Annual net dividend	Annual dividend per capita[a]
1	25			25	0,75	18,75
2	25			50	1,50	37,50
3	25			75	2,25	56,25
4	25			100	3,00	75,00
5	25			125	3,75	93,75
6	25	25		175	5,25	131,25
7	25	25		225	6,75	168,75
8	25	25		275	8,25	206,25
9	25	25		325	9,75	243,75
10	25	25		375	11,25	281,25
11		25	25	425	12,75	318,75
12		25	25	475	14,25	356,25
13		25	25	525	15,75	393,75
14		25	25	575	17,25	431,25
15		25	25	625	18,75	468,75
16			25	650	19,50	487,50
17			25	675	20,25	506,25
18			25	700	21,00	525,00
19			25	725	21,75	543,75
20			25	750	22,50	562,50
			Millions DKr[b]			DKr[b]

a. Based on a population of 40,000 eligible individuals.
b. 1 DKr approximately equals C$0.2

A further problem arises if the Danish government appropriates the majority of revenues in excess of DKr 500 million. If Greenland has obtained control over the management of mineral resources, then there is an incentive to seek a greater share of the rents through other means than the tax system. Possibilities abound, but they all involve some form of additional operating cost for the mine. It must be noted, that this kind of competition for mineral rents is not uncommon, as shown by the case of multilateral allocation of rents from low-sulfur coal in the western US (Wyoming) (Atkinson and Kerkvliet 1986).

The problem in both these cases is that the transfer of resource management to the Home Rule Authority, rejected for other reasons in chapter 7 and 8, is incompatible with the revenue-sharing agreement. Thus a savings and sharing model is required to avoid these problems. The model presented above in figure 9.2. can be extended to cope with the additional revenues, at least in part. Complete elimination of the problem is only possible if the revenue sharing agreement is canceled, and all revenues accrue to Greenland.

Taking the upper right-hand corner of figure 9.2, a separate trust fund can be developed for revenues exceeding DKr 500 million. This fund, here named the "Greenland Transfer Equalization Fund", will receive the additional revenues and accumulate them as a principal, which is to be invested in low risk securities. The investment income is used for two purposes, first to compensate for inflation, and second to reduce annual unrequited transfer payments. The difference between this model, and the direct use of all revenues to reduce transfers, is that this model allows the Greenland Home Rule Authority to accumulate a pool of capital, which will allow it greater independence of the Danish Government.

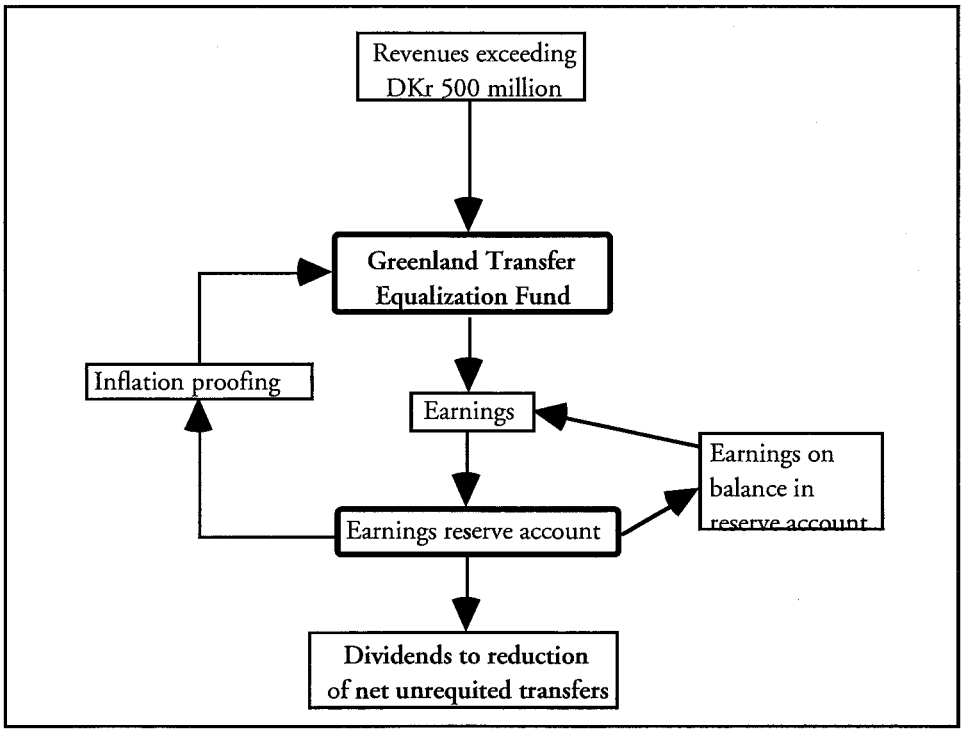

Figure 9.3. The Greenland Transfer Equalization Fund, developed from figure 9.2.

Employment and training of local labour

Substantial employment of Greenlandic labour at future mines is not an impossible goal, as shown by the experiences from the Black Angel Mine. The important issues related to such employment must, however, be resolved. This section considers some of the areas related directly to the employment and training aspect of mineral development, while the issue of mining communities is examined in the following section. The areas considered here are the mining company's employment and training commitment, the work conditions for local labour, its competitiveness relative to imported labour, and the effects of the mine on local labour market conditions.

The use of training and education as part of a development strategy related to mines is frequent, as shown for example in the Nanisivik case. The Canadian practice of entering into socio-economic agreements is one possible approach, although limited by the special treatment it gives aboriginal employees. The cases presented above identify both lack of an enforcement mechanism, and problems with the assumptions regarding the suitability of local residents for mine work, which underlie the agreement, as major problem areas.

The enforcement problem is basically related to cost of alternative staffing options. Mining companies are interested in using the cheapest available labour under the circumstances, its cost determined by wages, training cost and productivity. The need for special agreements indicates that employment of local residents would not take place without the agreements, and that local labour is not competitive with labour imported from the South. The agreement may be seen as one way of bringing the qualifications of local residents up to a level where they can compete with imported labour.

The alternative is for society to invest in a population which is generally better trained and educated, and therefore able to take up opportunities offered by mineral resource projects on equal terms with imported labour. In the case of Greenland the educational system consists of an extensive system of primary schools, which provide the minimum 9 years of basic education.

In addition, there is a possibility to stay in the primary school system for another 3 years. In terms of secondary school there is a choice between academic or vocational directions. The academic option is designed to enable students to enter higher education while the vocational training option is divided into a number of different areas. Thus it is possible to obtain training in metalworking, construction, commerce, fishing industry disciplines (including seamanship), and food production[89]. This indicates that Greenland has the potential to supply workers trained in a number of relevant disciplines (mainly metalworking and construction), and also the framework needed to set up dedicated training for mining. In addition, it should be noted that past mining activities, which have employed Greenlanders, has created a group of people who have a long tradition for association with mining. This has primarily been related to the Qutdlissat coal mine, and the Black Angel Mine.

The second issue related to employment of local or regional residents is the extent to which such employment enables the pursuit of traditional activities. Again the argument about cost and competitiveness apply. It is likely, however, that work rotations can be arranged without imposing significant extra costs on the company, possibly even in such way as to accommodate individual preferences. The experience from Nanisivik, where some inuit employees preferred to accumulate free time (of which they have more than non-inuit employees), and then use it for an extended period of hunting during summer, indicates that flexibility may achieve valuable results.

Finally, with respect to the potential impact of mine developments on local labour markets, three characteristics must be noted, which do not indicate great problems associated with development of mines. The mines typically operating in the Arctic have between 200 and 400 employees in total. If the recruitment for staff occurs over an extended period during construction, and the first year of operation, the effect on the local labour market will not be extreme. It is

89 All information on the educatiuonal system are taken from the 1991 edition of the Greenland Yearbook.

clear that labour, once it has become integrated at the mine, will have an incentive to seek higher wages as part of an effort to gain a share of mineral rents, and that this may create some of the "resource movement" effect discussed in chapter 3.

Despite this possibility, other circumstances may counterbalance it. These are primarily that unemployment in Greenland was between 6% and 11 % of the population in the towns (see chapter 2), and that this unemployment is the result of retrenchment in the fisheries sector to protect stocks, (and also in part due to the closure of the Black Angel Mine).

Mining communities

The final area where management of the mineral industry plays an important role in with implication for Greenland is the choice between a mining camp, or a mine town-site. Here we use the first term to describe operations where only workers live on site during their period of duty, an approach also sometimes referred to as commuter rotation (DePape 1984). The second term refers to operations where workers live on, or near the mine site with their families.

For future mines in Greenland, a number of possibilities must be considered. A partly useful classification by Glass and Lazarovich (1984) provides the basic idea, by identifying four distinct situations, based on Canadian experiences:

1. Orebodies with a relatively short life-span in a remote location;
2. Orebodies with a longer life in an area which could support regional development;
3. A number of orebodies in areas with existing communities nearby;
4. A number of orebodies with long life expectancies located in relatively remote locations.

Location and size of the orebody can be used as the two basic variables determining the most suitable type of accommodation. Location can be thought of as distance to, and accessibility of, existing communities able to supply labour. It can also refer to the distance from a new mining town to existing larger communities, and to infrastructure, all of which can enable the new town

to develop sustainable economic relations. Using this approach, the choice between different types of accommodation can be described, as shown in the following diagram:

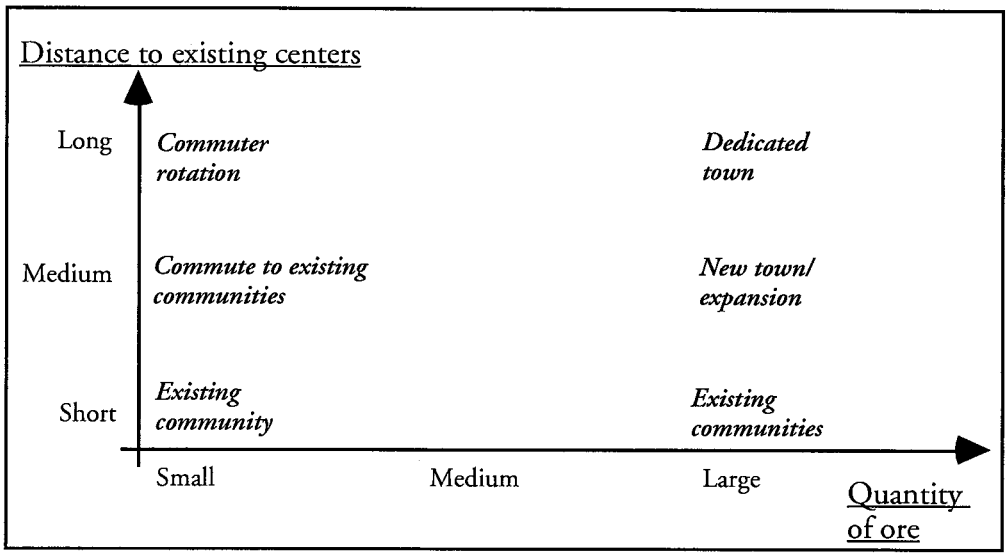

Figure 9.4. Possible accommodation strategies for mine developments. Quantity of ore refers not only to individual deposits, but also the total volume of ore in an area.

The actual choice of accommodation depends on other factors as well, most notably the quality of labour available under alternative accommodation strategies. Experience from Cominco's Polaris operation, for example, indicates that the fly in/fly out type of operation tends to attract persons with relatively few family commitments, and that persons with a family finds the lifestyle unacceptable for more than 2 years (Douglas 1984). In relation to inuit employment, Dahl (1984) notes that one of the principal complaints expressed by Greenlanders working at Maarmorilik was the separation from their families (Dahl 1984).

CONCLUDING REMARKS - SOME OF MANY ASPECTS OF INDIRECT MANAGEMENT

The three case studies, which highlighted the great need for communication with local communities and the problems of achieving spin-off benefits, introduced some realism from real-life problems of mining developments into the not always well-founded optimism of government

planners. An approach used in Canada to solve a wide range of problems related to aboriginal employment in the mineral industry was then examined. This approach is partly based on what seems to be an incomplete understanding of how the industry works. The basic problem is that the socio-economic agreements uses mining projects to solve problems which basically have little to do with mining (including northern underemployment and lack of alternative opportunities for aboriginal people).

On a more idealistic note, the discussion of trust funds proposed a practical solution to the more fundamental capital accumulation problem, first raised in chapter 3. The proposal for a Greenlandic version of the trust fund concept is aimed partly at this problem, which is especially acute in the Arctic, where investments in renewable resources are difficult. In addition, the proposal for the Greenland Trust Fund was seen as a way of solving the long-running conflict over resource control, which has prevented comprehensive reform of the Mineral Resource Administration.

The evidence from the case studies, and the discussion of alternative accommodation strategies, highlighted the fact, that for all practical purposes, Greenland can choose between dedicated town-sites with a life-expectancy corresponding to that of the mine, and fly in/fly out operations. The exception is orebodies discovered close to existing towns or settlements.

10

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The preceding chapters have covered a range of topics related to Greenland's possibilities for developing a mining industry. The following sections gather the various lines of argument to form an integrated statement of the problems, opportunities, and possible courses of action facing decision-makers responsible for Greenland's future mineral policy.

Before proceeding, however, it is natural to state the principal conclusions of the present study in point form.

1. The literature on a range of mineral policy issues has been examined and three principal components of any mineral policy identified. These are mineral development policies which can cope with the constraints of depletion, economic management of mineral activities (especially rent capture and efficient regulation), and technical management (specific design of property rights, regulations and government support services).

2. The past and present mineral policies in Greenland have been examined and analyzed and it is concluded that while considerable improvements have been made in recent years, the existing policy is not ideal for attracting investment, or for making minerals an excepted part of the Greenland economy.

3. Based on the mineral policy areas identified and the conclusions concerning the present mineral policies a proposal for a new mineral policy for Greenland has been drawn up.

4. Three case studies highlight some of the more practical problems of attaining the short term benefits associated with mineral development in remote areas with indigenous population groups.

The present chapter begins with a brief discussion of Greenland's present situation, both in terms of the constraints under which the economy must operate, and in terms of the existing features on which efforts to promote Greenland as an investment target must be built. The second section takes in the four aspects of policymaking which are equally important to Greenland's possibilities for achieving success as a mining country. These are overall economic policy, handling of economic impacts from mining, taxation, and technical regulation of mineral activities. Section three returns to the analysis of Greenland's past and present mineral policies in chapters 6 and 7, emphasizing the incompleteness of recent reforms. Finally, we return to the more specific aspects of regulation, summarizing the policy recommendations, both those stated precisely in Chapter 8 with respect to economic, technical, and practical matters, and those stated more implicitly in the course of the discussion, in Chapter 9, of the cases and the use of a trust fund for managing [part of] mineral revenues.

The final section steps back from the case of Greenland, and discusses those areas where more research is relevant and needed, both with respect to the future of Greenlandic mineral policy, and regarding a number of more generally interesting issues.

GREENLAND'S SITUATION AND THE POTENTIAL FOR MINING

The structure of Greenland's economy means that the possibilities for creating economic growth and improving the standard of living are severely limited. The narrow resource base, and the unrequited transfers from Denmark are the most important constraints. Other, less

permanent problems noted in chapter 2, were the accumulated debt of the Greenland Home Rule Authority, the scarcity of skilled labour, and the extremely large public sector. Less visible, but still important, is the dispersed settlement pattern which involves considerable cost to the Home Rule Authority, and the existence of many local and small markets which inhibit competition in some important transactions.

Despite these problems, one of the most remarkable features about Greenland has been the Home Rule Authority's ability to adapt economic policy when the need really arose. The budgetary improvements achieved in the late 1980's indicate that, if necessary, major policy initiatives can be implemented.

The desire to widen the resource base by attracting mineral investment, initially for exploration, is a natural consequence of the problems facing Greenland. In order to obtain results in this strategy, Greenland has been the driving force behind the changes in mineral policy and legislation which has taken place over the last 3-4 years, starting with the 1990 strategy report discussed at length in chapter 7. The process is not yet complete, a major goal for the Greenland Home Rule Authority still being the transfer of the Mineral Resources Administration to Greenland and Home Rule Control. The question still is, however, whether Greenland has the prerequisites needed to develop a mining sector which can make a significant contribution to the Greenland economy.

The first of these prerequisites is the existence of a favourable resource potential. In this area, ranking of various countries according to mineral potential would not be to Greenland's advantage. The primary reason is the considerable extent of high-grade metamorphic terrains in Greenland, covering much of the West coast and parts of the Southeast coast. However, a number of different target terrains hold some promise for discovery of certain types of deposits, among them gold veins in greenstone rocks, and massive sulfides in both volcanic and sedimentary settings.

The second prerequisite is accessibility. In this respect Greenland is not in a very good position. The island is remote, the climate harsh and uninviting. Although partially compensated by the relatively easy access to tidewater, the accessibility problem is compounded by the very limited infrastructure outside towns, settlements, and (present or former) military bases.

The third prerequisite is a stable and favourable investment climate. The extensive analysis in Chapter 7 showed that the most recent revision of the Greenland Mineral Law involved improvements, particularly with respects to security of tenure and mining taxation. Similarly, the stable political climate in Greenland and Denmark, and the existence of a fully developed system of legally protected property rights, are both favourable characteristics. However, the analysis also pointed to a number of discrepancies, ambiguities and areas of regulation where little, or no effort, has been made to state intended policies. If these problems were resolved, removed, or clarified along the lines proposed in chapter 8, Greenland would have a quite good point of departure for attracting investors.

The fourth prerequisite is investment in mineral exploration. The record of such investments in Greenland in recent years is the only available measure of investor interest. At around DKr 20-30 million annually (approximately C$ 4-6 million) the level of exploration investment is less than half a percent of annual world investments in exploration, and much lower than the average discovery cost of one economic mineral deposit in Canada. Furthermore, at a time when vast sums of exploration investment from North America are seeking less heavily regulated pastures, it is somewhat strange that Greenland has not received more attention.

It may be premature to judge the effect of the 1991 policy reform, but it is likely that the recorded increases in exploration can be directly attributed to large individual projects, and that the increase does not reflect a significant trend.

THE FRAMEWORK FOR MINERAL DEVELOPMENT

The introduction identified four aspects of policy-making which are important to Greenland's, or any other country's, possibilities of achieving success in mining. Overall economic policy has not been explicitly discussed except in the reference made to Greenland's ability to pursue very tight fiscal policies when the need arose. The underlying assumption for the discussion is, however, that governments have, and will continue to have, economic policies which provide a tolerable environment for private investment.

This being said, there is a distinction between long term policy issues, more immediate concerns, and current problems. The long-term perspective was discussed in chapter 3, and also in chapter 9. The important basic element of a sustainable policy was identified as capital accumulation, while the companion definition emphasizing the stock of natural capital was mentioned with a degree of reservation, resulting from a difficulty of finding good policy recommendations.

In contrast to the relatively obvious importance of capital accumulation and sustainability considerations, the discussion of the traditional benefits of mineral development (linkages and spin-off benefits) was not uplifting. The opportunities for lasting economic development based on mineral resources depends heavily on a number of factors which are not related to mining *per se*. In the case of Greenland, the lack of many of these non-mining factors indicates that permanent economic development based on downstream processing, and other spin-off benefits, may not occur. Only where a mineral province, containing many deposits, is found at a reasonable proximity to existing communities and markets, will there be an opportunity for such development.

The extended discussion of taxation, and other economic aspects of mineral industry regulation, had as its underlying theme a concern for the efficiency of the mining industry. Emphasizing efficiency in both exploration, production, and abandonment of mines, contributes to making the total amount of benefits, available for sharing between the interested parties, as

large as possible. Unfortunately, the pursuit of these goals is not always easy, when customs and traditions play an important role. This means that while the preferred recommendation on how to award mineral titles is cash bidding/auction, the structure of the mineral industry makes the tradition for discretionary titles, or claims-based titles, very difficult to evade, especially for a small country wishing to attract as many investors, and as much investment as much as possible.

The need to follow traditions was reflected in the discussion in chapter 5, on the technical regulation of mineral projects. As a result of the analysis, the principal issue in technical regulation is the link between exploration title and the right to produce minerals from deposits discovered. Despite information problems, likely to be formidable in some cases, land use planning and zoning was emphasized as a possible way to determine the general suitability of land for exploration access.

The discussions of various aspects of mineral resource management had an underlying set of economic arguments. These can be summarized in point form as follows:

1. Resource rights should ideally be sold, not given away;
2. Sale and leasing of resource rights should take place at market prices;
3. If resource rights are being, or have been allocated in other ways, they should be easily tradable, and combination and division of rights should be as easy as possible;
4. All external and internal costs of title disposition, exploration, development, production, and abandonment should be recognized;
5. Resource management systems should be able to adapt smoothly to the numerous fluctuations affecting the mining industry;
6. The risk of revenue fluctuations should be shared between the state and private mining firms;

7. The credibility of the resource disposition system is extremely important and changes should be undertaken only when strictly necessary, and never in an incremental way.

THE MINERAL POLICIES OF GREENLAND, NOW AND IN THE RECENT PAST

The more recent events in mineral policy-making in Greenland include the 1965 Mineral Law, the amendments introduced with Home Rule in 1978, and the 1991 policy reform leading to the existing Mineral Law. During the period from 1979 to 1991, a number of additions to mineral policy, some enacted as amendments to the Mineral Law, others implemented administratively, contributed to making investment in mineral exploration highly unattractive.

The present organization of power in relation to mineral resources was the result of a political compromise. Perhaps the existence of the Joint committee, and the ministry-based MRA, reflects that the strongest party in the Home Rule negotiations, Denmark, saw the control of the administration as the key to controlling the resources. The result has contributed to the serious problems discussed in chapters 6 and 7. A characteristic part of these was the options for the joint Greenlandic-Danish petroleum exploration company Nunaoil, to buy into any project *ex post*, at low risk. The generally positive attitude to government-owned enterprises in Greenland, and the tradition in Danish off-shore petroleum policy for a similar approach can explain the option approach in the case of the Jameson Land petroleum concession. However, the extension of this policy to metallic minerals cannot easily be explained in the same way, particularly when the existing state mineral enterprises in this sector have not been known for their success as operators. If the intention was to use the state participation as a rent collection tool, it would have been simpler to adopt a variation of the Resource Rent Tax.

It was the circumstances at the time, particularly the lack of revenue-sharing, which made the option policy preferable to Greenland. When the agreement to share revenues was signed in 1988, Greenland's incentive to continue the state company policy diminished signi-

ficantly. Because revenues from the state company were to be included in the total pool available for sharing, the cap on revenues shared equally meant that the incentive to keep the state company remained.

When, in 1989-90, it became clear that the Black Angel mine would close definitively in the summer of 1990, a major effort to remove investor-hostile elements from the mineral policy was launched. Furthermore, the mineral policy review was completed in a remarkably short time during the spring of 1990. Soon afterwards, the new Mineral Law was drafted, and enacted in May 1991. After that, the "Principles and Procedures", and the various "Standard Terms" emerged at a slower rate during 1991 and 1992.

The sequence of events in mineral policy since 1979, the lack of attention to exploration investment, and the incomplete, and inconsistent result of the policy review indicates the principal problem. In character, the mineral policy-making in Greenland has been reactive, where it should have been proactive. Action has been taken only when dictated by events, and then primarily at the behest of the Greenlandic side of the Joint Committee.

DESIGN AND IMPLEMENTATION OF DIRECT MANAGEMENT

Despite the admonition not to tinker with mineral policy at short intervals, the case of Greenland is one still in need of change. The latest attempt to adapt policy within the existing regulatory and political framework was incomplete, partly because the changes happened quickly, and partly because not all of the fundamental issues were analyzed in detail. Therefore it is necessary to start anew on designing a mineral policy.

The discussion in chapter 8 served to outline the basic elements of what should go into a mineral policy for Greenland. The first step was to separate the minerals from the constitutional debate over ownership, and metallic minerals from petroleum. Secondly, a clear qualitative objective was recommended.

With the ownership problem pushed to the back of the agenda, attention can be concen-

trated on devising a political institution under which joint management can proceed. As long as Denmark has a fiscal interest in Greenland (i.e. as long as the unrequited transfers continue), this involves providing the Joint Committee with the power to make major policy decisions, as well as with information and advice, which is not influenced by the strategic considerations of either the Greenlandic or Danish government. If the Mineral Resources Administration is forced to remain under the Danish Government, or if it is transferred to the Home Rule Authority, the Joint Committee must be provided with a separate secretariat, which is not subject to partisan interests. The more appealing, and probably more efficient, alternative is to place the MRA directly under a more powerful version of the Joint Committee.

Under this model, the MRA should be more integrated with its technical agencies than it is at present. At the same time the administration must be divided between Greenland and Denmark, with the research-oriented activities remaining in close contact with the Danish Universities, while the administrative branch moves to Nuuk. An integral part of a transfer to Nuuk would be the employment and training of Greenlandic staff for this part of the operation.

The discussion of economic terms emphasized the importance of providing a regulatory framework with as few distortions as possible, a taxation package which is competitive without loosing its own credibility, and environmental regulations which emphasize restraint by involving rigorous analysis of economic costs and benefits in the determination of required abatement measures.

The central feature in the proposed technical regulation is the principle that if access has been allowed, and an exploration right issued, then there is no way such a right can be rescinded, except when the holder grossly breaks laws and regulations, for example by ignoring basic rules governing conduct during exploration. Such a policy requires some (as much as possible) information on which to base land use and exploration access decisions, and also a realization that when mistakes are made, which is likely to happen, this must be accepted as one of the costs of learning by doing.

Despite a very solid right to develop a discovery, it will not be possible to avoid determination of environmental constraints. In the absence of well-developed economic tools for environmental management in mining, this must rely on the traditional "command and control" approach. This will have to involve a negotiation process between investor and regulator, and possibly some provision for arbitration when agreement cannot be reached.

INDIRECT MANAGEMENT

The cases presented in chapter 9 portrayed three Arctic mines and the effects they have had. The major local and regional effects have been through the wages paid to workers recruited locally or regionally. In contrast, government revenues have not been mentioned in the Canadian cases, and have mainly accrued to Denmark in the Black Angel case, the exception being the revenues to Greenland under the 1988 revenue sharing agreement.

One of the most interesting messages from the three case studies is the importance of information to local communities. This message is relevant for both mining companies, who depend on local goodwill and acceptance, but especially for the government or the regulator. For the latter the cases point to the need for a framework in which the concerns of local communities can be addressed, taking into account those areas where it is relevant to have local influence.

When local relations are discussed, the most important matter is frequently employment opportunities created by the mine. The case evidence is ambiguous on this point, one of the mines may have very few aboriginal or local employees, and no agreement on employment, while another mine has a considerable number, albeit far below the originally agreed number. Finally, there is the mine where employment at one point is higher than elsewhere, but where the number of local residents employed declines as the closure approaches. The evidence is thus mixed and sensitive to specific circumstances. The policy of contracting between mining firms and government in order to achieve a wide range of socio-economic go-

als was viewed with some skepticism, partly as a result of the enforcement problems in such contracts, and partly because of the possibility of introducing distortions of incentives for efficient operation. The alternative is to pay close attention to the competitiveness of local workers, even if this requires that the Greenland Home Rule Authority has to commit resources to training in this area.

The third part of chapter 9 began with a lengthy digression on trust funds. The examination of the two largest, and very different funds in Alaska and Alberta, served to highlight the problems and opportunities involved in such funds. The conservative, risk-averse and politically independent Alaska Permanent Fund has succeeded in providing all residents of the state with handsome annual payments. The development-oriented and politically controlled Alberta Heritage Savings Trust Fund has received much greater revenues in total, but has been used to further political and regional development goals. The provincial government has long ago stopped paying anything into the fund from resource revenues , has managed to consume most of the investment income, and has also omitted to inflation-proof the principal capital.

The chief lesson to be drawn from the two funds was the need for conservative investment policies, funds independent from short-term political considerations, and a mechanism which give residents a direct reason for being concerned with the fund's performance.

The purpose of discussing these funds was to propose a similar fund for Greenland, specifically to facilitate compromise on, or postponement of, the ownership debate. The principal revenues to this fund would be derived from the Greenlandic mineral revenues accruing to the Danish treasury. Additional appropriations are possible from Greenland's share of revenues, and in the event of revenues exceeding the DKr 500 million, specified in the 1988 revenue sharing agreement (see chapter 7). The simple model used to illustrate the development of such a fund showed that very large revenues are required to provide a substantial sum to the residents of Greenland.

The issue of employment is closely related to one key decision at the time of mine development, the choice between building a town site or limiting development to a mining camp without accommodation for families of employees, and the associated development of services. The choice depends on a number of factors, but these can be reduced to two key factors, distance to an existing center or town, and quantity of ore. The decision rule is very simple, the larger the deposit(s), and the longer the distance, the more relevant is a dedicated town site.

SUGGESTIONS FOR FURTHER RESEARCH

Two areas of possible further research can be identified. One is related to the economic understanding of exploration policy and of the mechanisms influencing the choice of policy instruments. This can be analyzed both in theoretical models, and through empirical studies of the investment patterns in mineral exploration, in relation to the structure of property rights institutions and information availability. This area also includes improving the understanding of internal decision-making in exploration firms, primarily based on the rapidly expanding field of industrial organization and the economics of organizations.

The second area is specifically related to Greenland, and involves a closer investigation into the comparative advantage of Greenlandic labour, both specifically in relation to the mining sector, and more generally. Within this area it may also be possible to utilize the data from the cryolite company, which have been preserved in the national archives of Denmark for posterity. These data may, as noted in chapter 6, be an invaluable source of data on the behaviour of a natural resource monopolist.

References

Adams, F. Gerard and Bernhard Duroc-Danner. "Measuring competitive costs in non-ferrous metal production." *Resources Policy* Vol. 13 [3] (1987): 166-174.

Adelman, M.A. "Mineral depletion, with special reference to petroleum." *Review of Economics and Statistics* Vol. 72 [1] (1990): 1-10.

Alaska Permanent Fund. Annual Report 1991-92. Juneau: Alaska Permanent Fund Corporation, 1992.

Alberta Heritage Savings Trust Fund. Annual Report 1991-92. Edmonton: Alberta Heritage Savings Trust Fund, 1992.

Allart, J.H. "Ketilidian Mobile Belt in southern Greenland." In Geology of Greenland, ed. A. Escher and W.S. Watt. p. 120-151. Copenhagen: Geological Survey of Greenland, 1976.

Anders, G.C. "Rent-seeking, predatory economies and lopsided development." In Western Regional Science Association AGM, San Diego, 1988.

Anderson, F.J. Natural Resources in Canada. 2nd ed., Scarborough, ON: Nelson Canada, 1991.

Atkinson, S.E. and J. Kerkvliet. "Measuring the multilateral allocation of rents: Wyoming low-sulfur coal." *Rand Journal of Economics* Vol. 17 [3] (1986): 416-430.

Auty, R.M. "Mismanaged mineral dependence. Zambia 1970-90." *Resources Policy* Vol. 17 (1991): 170-183.

Balassa, B. A "stages" approach to comparative advantage. Vol. 256. World Bank Staff working paper, The World Bank, 1977.

Barford, P. "The Greenlanders and the Europeans in Greenland: The administrative distinction between the Greenlandic and European population in Greenland in censuses and through laws and other regulations." In International Workshop on Population Issues in Arctic Societies., Montreal, edited by K. De La Barre, Departément de Démographie, Universite de Montreal, 1985.

Barnett, H.J. "Scarcity and groowth revisited." In Scarcity and growth reconsidered, ed. V.K. Smith. p. 163-217. Baltimore: Johns Hopkins University Press, 1979.

Barnett, H.J. and C Morse. Scarcity and growth: The economics of natural resource scarcity. Baltimore: Johns Hopkins University Press, 1963.

Barzel, Y. Economic analysis of property rights. Cambridge: Cambridge University Press, 1989.

Barouch, E. and G. Kaufman. "Probabilistic modelling of oil and gas discovery." In Energy, Mathematics and Models, SIAM Institute for Mathematics and Society, 1976.

Baumol, W.J. and W.E. Oates. The theory of environmental policy. 2 ed., Cambridge: Cambridge University Press, 1988.

Bergstrom, T.C. "Property rights and taxation in the Australian minerals sector." In The minerals sector and the Australian economy, ed. L.H. Cook and M.G. Porter. p. 175-189. Sydney: George Allen and Unwin Australia, 1984.

Berthelsen, C., I.H. Mortensen, and E. Mortensen. "Grønland Atlas." Nuuk: Grønlands Hjemmestyre, 1989.

Bjerke, K. and N. Ussing. Studier over Danmarks Nationalprodukt 1870-1950. Copenhagen: Gads Forlag, 1958.

Bosson, R. and B. Varon. The mining industry and the developing countries. New York: Oxford University Press, 1977.

Bradley, P.G., J.F. Helliwell, and J.R. Livernois. "Efficient taxation of resource income The case of copper mining in British Columbia." *Resources Policy* Vol. 7 [3] (1981): 161-170.

Bradley, P.G: and G.C. Watkins. "Net value royalties Practical tool or economist's illusion." *Resources Policy* Vol. 13 [4] (1987): 279-288.

Bridgewater, D., L. Keto, V.R. McGregor, and J.S. Meyers. "Archean gneiss complex of Greenland." In Geology of Greenland, ed. A. Escher and W.S. Watt. p. 18-75. Copenhagen: Geological Survey of Greenland, 1976.

Bromley, D.W. Environment and economy. Oxford: Blackwell, 1991.

Brown, E.C. "Business-income taxation and investment incentives." In Income, employment and public policy, essays in honour of Alvin D. Hansen, New York: Norton, 1948.

Bruun, R. and Mortensen, F.K. Maarmorilik. Copenhagen: Fiskers Forlag, 1991.

Buchanan, J.M. and R.E. Wagner. Democracy in deficit. New York: Academic Press, 1977.

Bush, W.C. and L.S. Mayer. "Some implications of anarchy for the distribution of property." *Journal of Economic Theory* Vol. 8 (1974): 401-412.

Clarke, D.B. and A.K. Pedersen. "Tertiary volcanic province of West Greenland." In Geology of Greenland, ed. A. Escher and W.S. Watt. p. 364-385. Copenhagen: Geological Survey of Greenland, 1976.

Coase, R. "The problem of social cost." *Journal of Law and Economics* Vol. 3 (1960): 1-44.

Colander, D.C., ed. Neoclassical political economy. Cambridge, MA.: Ballinger Press, 1984.

Corden, W. Max. "Booming sector and Dutch disease economics: Survey and Consolidation." *Oxford Economic Papers* Vol. 36 (1984): 359-380.

Corden, W. Max and J. Peter Neary. "Booming sector and de-industrialization in a small open economy." *Economic Journal* Vol. 92 (1982): 825-848.

CORE. Interim report on Tatshensini-Alsek Land Use, British Columbia. Victoria: Commission on Resources and Environment, 1993.

Cornes, R. and T. Sandler. The theory of externalities, public goods and club goods. Cambridge: Cambridge University Press, 1986.

Crommelin, M. "Mining and petroleum titles." *Australian Law Journal* Vol. 62 (1988): 863-877.

Dahl, J. "Mining and local communities." *Inuit Studies* Vol. 8 [2] (1984): 145-156.

Dahl, J. and K.J. Lyberth. Grønlandske migrantarbejdere i Marmorilik 1973-1978. Copenhagen: Institut for Ekskimologi, 1980.

Dam, K.W. Oil resources: Who gets what how? Chicago: Chicago University Press, 1976.

Dasgupta, P., R. Eastwood, and G. Heal. "Resource management in a trading economy." *Quarterly Journal of Economics* Vol. 92 (1978): 297-306.

Dasgupta, P. and G. Heal. "The optimal depletion of exhaustible resources." *Review of Economic Studies* Vol. Symposium on the economics of exhaustible resources (1974): 3-28.

Dasgupta, P.S. and G.M. Heal. Economic theory and exhaustible resources. Cambridge: Cambridge University Press, 1979.

Davis, J.D., F.B. Larsen, and K.M.P. Nielsen. Offentlig styring af olie-gasaktiviteter i Grønland. Århus: Århus University, 1984.

Dawes, P.R. "Precambrian to Tertiary of Northern Greenland." In Geology of Greenland, ed. A. Escher and W.S. Watt. p. 248-303. Copenhagen: Geological Survey of Greenland, 1976.

Deer, W.A. "Tertiary igneous rocks between Scoresby Sund and Kap Gustav Holm, East Greenland." In Geology of Greenland, ed. A. Escher and W.S: Watt. p. 404-431. Copenhagen: Geological Survey of Greenland, 1976.

DePape, D. "Alternatives to single project mining communities: a critical assesment." In Mining communities: Hard lessons for the future. Proceedings of the Twelfth CRS Policy Discussion Seminar, Kingston, ON., Centre for Resource Studies, Queens University, 83-95, 1984.

Dogget, M.D. and B.W. Mackenzie. "What the alchemists didn't know: Comparing Canada's base metal and gold potential." *CRS Perspectives* [44] (1993): 22-31.

Douglas, R.P. "The industry perspective." In Mining communities: Hard lessons for the future. Proceedings of the Twelfth CRS Policy Discussion Seminar, Centre for Resource Studies, Queens University1984.

Eggert, R.G. Metallic mineral exploration: An economic analysis. Washington, D.C.: Resources for the Future, 1987.

Eggert, R.G. "Exploration." In Competitiveness in Metals: the impact of public policy, ed. M.J. Peck, H.H. Landsberg, and J.E. Tilton. p. 21-67. London: Mining Journal Books, 1992.

Emeleus, C.H. and B.G.J. Upton. "The Gardar period in southern Greenland." In Geology of Greenland, ed. A. Escher and W.S. Watt. p. 152-181. Copenhagen: Geological Survey of Greenland, 1976.

Emerson, C. "Mining enclaves and taxation." *World Development* Vol. 10 [7] (1982): 561-571.

Emerson, C. and R. Garnaut. "Mineral leasing policy: Competitive bidding and the resource rent tax given various responses to risk." *Economic Record* Vol. 60 (1984): 133-142.

Escher, A. and T.C.R. Pulvertaft. "Rinkian Mobile belt of West Greenland." In Geology of Greenland, ed. A. Escher and W.S. Watt. p. 104-119. Copenhagen: Geological Survey of Greenland, 1976.

Escher, A., K. Sørensen, and H.P. Zeck. "Nagssugtoqidian mobile belt in West Greenland." In Geology of Greenland, ed. A Escher and W.S. Watt. p. 76-95. Copenhagen: Geological Survey of Greenland, 1976.

Faber, M. and R. Brown. "Changing the rules of the game: Political risk, instability and fairplay in mineral concession contracts." *Third World Quarterly* Vol. 2 [1] (1980): 100-119.

Fane, G. and B. Smith. "Resource Rent Tax." In Australian Energy Policies in the 80's, ed. C.D. Trengove. p. 209-248. North Sydney: Allen & Unwin Australia, 1986.

Fisher, A.C. Resource and environmental economics. Cambridge: Cambridge University Press, 1981.

Foigel, I. Home Rule in Greenland. Vol. 1/1980. Meddelelser om Grønland, Man and Society, Copenhagen: Commission for scientific research in Greenland, 1980.

Gad, F. Grønlands historie Vol. III. Copenhagen: G.E.C. Gad, 1967.

Gad, F. Grønland. Copenhagen: Politikens Forlag, 1984.

Garnaut, R. and A. Clunies Ross. "Uncertainty, risk aversion and the taxing of natural resource projects." *Economic Journal* Vol. 85 (1975): 272-287.

Garnaut, R. and A. Clunies Ross. "The neutrality of the resource rent tax." *Economic Journal* Vol. 55 (1979): 193-201.

Garnaut, R. and A.C. Ross. Taxation of mineral rents. Oxford: Clarendon Press, 1983.

Gary, M., R. McAfee Jr., and C.L. Wolf, ed. Glossary of Geology. Washington D.C.: American Geological Institute, 1974.

Gaskins, D. and T Teisberg. "An economic analysis of presale exploration in oil and gas lease sales." In Essays on industrial organization in honor of Joe S. Bain, ed. R. Masson and P. Qualls. Cambridge: Ballinger, 1976.

Gelb, A. and and associates. Oil Windfalls: Blessing or Curse. New York: Oxford University Press, 1988.

Georgescu-Roegen, N. "The entropy law and the economic problem." In Toward a steady state economy, ed. H. Daly. San Francisco: Freeman, 1973.

Gilbert, R.J. "Search strategies and private incentives for resource exploration." In Economics of energy and resources, ed. R.S. Pindyck. p. 149-169. Greenwich, Conn.: JAI Press, 1979.

Gilbert, R.J. "The social and private value of exploration information." In Economics of exploration for energy resources, ed. J.B. Ramsey. p. 173- 215. Greenwich, Conn.: JAI Press, 1981.

Gillis, M. Taxation and Mining: Non-fuel minerals in Bolivia and other countries. Cambridge, MA: Ballinger Publishing Company, 1978.

Gillis, M. Mineral taxation in Indonesia. Cambridge, MA: Ballinger, 1980.

Gordon, R.H. and J.K. MacKie-Mason. "Why is there corporate income taxation in a small open economy? The role of transfer pricing and income shifting." Dept. of Economics, University of Michigan Mimeo, 1993.

Graham, K. A. Eastern Arctic study case study series: The development of the Polaris Mine. Kingston, Ontario: Center for Resource Studies, 1982.

Greenex. Annual Report 1989. Greenex A/S, 1990.

Gregory, R.G. "Some implications of the growth of the mineral sector." *Australian Journal of Agricultural Economics* Vol. 20 (1976): 71-91.

Grønning-Nielsen, L. Redegørelse om statens salg af aktier i Kryolitselskabet Øresund A/S. Ministry of Justice, Government of Denmark, 1987. Judicial inquiry

Harberger, A.C. World economic growth. San Francisco: Institute for Comtemporary Studies, 1984.

Hardin, G. "The tradegy of the commons." *Science* Vol. 162 (1968): 1243-1248.

Harhoff, F. "Greenland's withdrawal from the European Communities." *Common Market Law Review* Vol. 20 [1] (1983): 13-33.

Harhoff, F. Den Grønlandske råstofordning. University of Copenhagen, 1985. Studie 7.

Harhoff, F. Rigsfællesskabet. Århus: Forlaget Klim, 1993.

Harpøth, O., J.L. Pedersen, H.K. Schønvandt, and B. Thomassen. The mineral occurrences of central East Greenland. Vol. 16. Meddelelser om Grønland, Copenhagen: The commission for scientific research in Greenland, 1986.

Harris, D.P. Mineral resources appraisal - mineral endowment, resources and potential supply: Concepts, methods, and cases. Oxford: Clarendon Press, 1984.

Harris, J.R. and M. Todaro. "Migration, unemployment and development: A two-sector analysis." *American Economic Review* Vol. 60 (1970): 126-142.

Hartwick, J.M. "Intergenerational equity and the investing of rents from exhaustible resources." *American Economic Review* Vol. 67 [5] (1977): 972-974.

Hartwick, J.M. and N.D. Olewiler. The economics of natural resource use. New York: Harper Collins, 1986.

Heal, G. "Aspects of natural resource depletion." In The economics of natural resource depletion, ed. D.W. Pearce. New York: Wiley, 1975.

Henderson, G. "Petroleum geology." In Geology of Greenland, ed. A. Escher and W.S. Watt. p. 489-505. Copenhagen: Geological Survey of Greenland, 1976.

Hendricks, K. and R. Porter. "An empirical study of an auction with asymmetric information." *American Economic Review* Vol. 78 (1988): 865-883.

Henriksen, N. and A.K. Higgins. "East Greenland Caledonian fold belt." In Geology of Greenland, ed. A. Escher and W.S. Watt. p. 182-247. Copenhagen: Geological Survey of Greenland, 1976.

Hirschman, A.O. The strategy of economic development. New Haven, CT: Yale University Press, 1958.

Hjemmestyrekommissionen. Hjemmestyre i Grønland. Vol. 1. Copenhagen: Government of Denmark, 1978.

Hotelling, H. "The economics of exhaustible resources." *Journal of Political Economy* Vol. 30 [2] (1931): 137-175.

Johnson, C.J. and W.S. Pintz. "Minerals and the developing economies." In Economics of the mineral industries, ed. W.A. Vogely. p. 19-50. 4th. ed., Vol. New York: American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., 1985.

Kamien, M.I. and N.L. Schwartz. "Optimal exhaustible resource depletion with endogenous technical change." *Review of Economic Studies* Vol. 45 (1978): 179-196.

Kjær Sørensen, A. Grønland i det 20. århundrede. Copenhagen: Gyldendal, 1983.

Klaassen, L. and T.H. Botterweg. "Project evaluation and intangible effects: A shadow price approach." In Environmetal Economics, ed. P. Nijkamp. Leiden: Marius Nijhoff, 1976.

Kuehne, G. and F. J. Trelease. "The new West Greman mining law." *Land and Water Law Review* Vol. 19 [2] (1984): 371-394.

Kumar, R. "Taxation for a cyclical industry." *Resources Policy* Vol. 17 [2] (1991): 133-148.

Leland, H. "Comment." In Mineral leasing as an instrument of public policy, ed. M. Crommelin and A.R. Thompson. p. 57-60. Vancouver: University of British Columbia Press, 1974.

Leland, H.E. "Optimal risk sharing and the leasing of natural resources, with application to oil And gas leasing on the OCS." *Quarterly Journal of Economics* Vol. (1978): 413-437.

Leshy, J.D. The mining law - A study in perpetual motion. Washington, D.C.: Resources for the Future, 1987.

Lewis, S.R. "Primary exporting countries." In Handbook of Development Economics, ed. H. Chenery and T.N. Srinivasan. Amsterdam: Elsevier Science Publishers, 1989.

Libecap, G.D. Contracting for property rights. Cambridge: Cambridge University Press, 1989.

Libecap, G.D. and S.N. Wiggins. "The influence of private contractual failure on regulation: The case of oil field unitization." *Journal of Political Economy* Vol. 93 (1985): 690-714.

Lidegaard, M. Grønlands Historie. Copenhagen: Nyt Nordisk Forlag Arnold Busck, 1991.

Lyck, L. Grønlands økonomi-og relationerne til Danmark. Copenhagen: Akademisk Forlag, 1986.

Lyck, L. "Natural resources in Greenland - Economic possibilities and restraints." *Nordic Journal of International Law* Vol. 57 (1988): 345-347.

Lyck, L. "Greenland: ten years of home rule." *Polar Record* Vol. 25 [155] (1989): 343-346.

Lyck, L. "Grønlands økonomi." Mimeograph: 1991.

Mansoorian, A. "Resource discoveries and 'excessive' external borrowing." Vol. 101 (1991): 1497-1509.

Martens, G. "Scenarios for Home Rule in Greenland after implementation of the plan for Home Rule." In Nordic Arctic Research on Contemporary Arctic Prolems, Gilleleje, Denmark, edited by L. Lyck, Aalborg University Press, p. 191-204, 1992.

Martinsen, B. "Subsidizing market failures." In Nordic Arctic Research on Contemporary Arctic Prolems, Gilleleje, Denmark, edited by L. Lyck, Aalborg University Press, 135-146, 1992.

McAfee, R.P. and J. McMillan. "Auctions and bidding." *Journal of Economic Litterature* Vol. 25 [2] (1987): 699-738.

Mead, W.J. "Cash bonus bidding for mineral resources." In Mineral leasing as an instrument of public policy, ed. M. Crommelin and A.R. Thompson. p. 46-56. Vancouver: University of British Columbia Press, 1974.

Mead, W.J., A. Moseidjord, and P.E. Sorensen. "Competitive bidding under asymmetrical information: Behaviour and performance in Gulf of Mexico drainage lease sales, 1959-1969." *Review of Economics and Statistics* Vol. 56 (1984): 505-508.

Meadows, D.H., D. Meadows, J. Randers, and W. Behrens. The limits to growth. New York: Universe Books, 1972.

Moorbath, S., R.K. O'Nions, and R.J. Pankhurst. "Early Archean age for the Isua iron formation, West Greenland." *Nature* Vol. 245 (1973): 138-139.

Morgan, D.R. "Fiscal policy in oil exporting countries, 1972-78." *IMF Staff papers* Vol. 26 (1979): 55-86.

Mumey, G and J. Osterman. "Alberta Heritage Fund: Measuring value and achievement." *Canadian Public Policy* Vol. 16 [1] (1990): 29-50.

Musgrave, R.A. The theory of public finance. New York: McGraw-Hill, 1959.

Muth, J.F. "Rational expectations and the theory of price movement." *Econometrica* Vol. 29 (1961): 315-335.

Nankani, G. Development problems of mineral exporting countries. World Bank, 1979. Staff working paper no.354.

Nappi, C. "Changing patterns of comparative advantage in North American metal mining." *Resources Policy* Vol. 15 [1] (1989): 24-44.

Neary, J.P and S. van Wijnbergen, ed. Natural resources and the macroeconomy. Oxford: Basil Blackwell, 1986.

Neher, Philip A. Natural resource economics. Conservation and exploitation. Cambridge: Cambridge University Press, 1990.

Nellor, D.C.L. "Taxation and the Australian resources sector." In The minerals sector and the Australian economy, ed. L.H. Cook and M.G. Porter. p. 191-248. Sydney: George Allen and Unwin, 1984.

Norton, D.A. Resource depletion and terms of trade collapse: the Zambian disease. University Colege, Dublin, Dept. of Economics, 1988. Working Paper WP88/2.

Nuttall, M. Arctic Homeland. London: Belhaven Press, 1992.

O'Brien, J.P. and D.C. Olson. "The Alaska permanent fund and dividend distribution program." *Public Finance Quarterly* Vol. 18 [2] (1990): 139-156.

OECD. Main Economic Indicators, Paris: OECD, 1955-.

OECD. General Statistics. Paris: OECD, 1962.

Ostrom, E. Governing the commons: The evolution of institutions for collective action. Cambridge: Cambridge University Press, 1990.

Pearce, D.W:, E. Barbier, and A. Markandya. Sustainable development: Economics and environment in the third world. Aldershot: Edward Elgar, 1990.

Pearce, D.W. and R.K. Turner. Economics of natural resources and the environment. Baltimore: Johns Hopkins University Press, 1990.

Pintz, W.S. Ok Tedi - Evolution of a third world mining project. London: Mining Journal Books, 1984.

Poole, G. "Fisheries Policy and economic development in Greenland in the 1980s." *Polar Record* Vol. 26 [157] (1990): 109-118.

Poole, G., M. Pretes, and K. Sinding. "Managing Greenlands mineral resources - A trust fund approach." *Resources Policy* Vol. 18 [3] (1992): 191-204.

Poole, G.R. "An economic analysis of development of Greenland's shrimp fishing and processing industry." In Nordic Arctic Research on Contemporary Arctic Prolems, Gilleleje, Denmark, edited by L. Lyck, Aalborg University Press, p. 65-78, 1992.

Poole, G.R. "The development of Greenland's shrimp fishing and processing industry since 1979: A study in applied economics." PhD thesis, Cambridge University, 1993.

Porter, R.C. "The new approach to wilderness preservation through cost-benefit analysis." *Journal of Environmental Economics and Management* Vol. 9 [1] (1982): 59-80.

Poulin, R. and K. Sinding. "Mining economics and the environment." *Natural Resources Forum* Vol. 17 [2] (1993a): 157-163.

Poulin, R. and K. Sinding. "Land use issues in mineral extraction." Paper no. 68, Canadian Institute of Mining and Metallurgy, 95th. Annual General Meeting, Calgary, 1993b.

Pretes, M. "Conflict and cooperation: The Alaska permanent fund, the Alberta heritage fund and federalism." *American Review of Canadian Studies* Vol. 18 [1] (1988):

Pretes, M. "Alaskan and Canadian trust funds as agents of sustainable development." In The legal challenge of sustainable development, ed. J.O. Saunders. p. 300-312. Calgary: Canadian Institute of Resources Law, 1990.

Pretes, M. and M. Robinson. "Beyond boom and bust: A strategy for sustainable development in the North." *Polar Record* Vol. 25 [153] (1989): 115-120.

Radetzki, M. "Where should deveoping countries' minerals be processed." *World Development* Vol. 5 [4] (1977): 325-334.

Radetzki, M. Uranium: A strategic source of energy. London: Croom Helm, 1979.

Radetzki, Marian. "Regional development benefits of mineral projects." *Resources Policy* Vol. 8 [3] (1982): 193-200.

Radetzki, M. State mineral enterprises in developing countries: Their impact on international mineral markets. Washington D.C.: Resources for the Future, 1985.

Radetzki, M. "Economic development and the timing of mineral exploitation." In Mineral wealth and economic development, ed. J.E. Tilton. p. 39-57. Washington, D.C.: Resources for the Future, 1992.

Ricardo, D. The principles of political economy and taxation. Everyman ed., London: Dent, 1911.

Robinson, M., M. Pretes, and W. Wuttunee. "Investment strategies for Northern Cash Windfalls: Learning from the Alaskan experience." *Arctic* Vol. 42 [3] (1989): 265-276.

Roemer, Michael. "Resource-based industrialization in the developing countries." *Journal of Development Economics* Vol. 6 (1979): 163-202.

Schiener, E.J. "Coal geology." In Geology of Greenland, ed. A. Escher and W.S. Watt. p. 506-517. Copenhagen: Geological Survey of Greenland, 1976.

Slade, M.E. "Trends in natural-resource commodity prices: An analysis of the time domain." *Journal of Environmental Economics and Management* Vol. 9 (1982): 122-137.

Slade, M.E. "Market structure, marketing method and price instability." *Quarterly Journal of Economics* Vol. 106 [4] (1991): 1309-1340.

Smith, B and A. Ulph. "Property rights issues in the extraction of Australia's exhaustible resources." In Industrial economics - Australian studies, ed. L.R. Webb and R.H. Allen. p. 395-409. London: George Allen and Unwin, 1982.

Smith, D.N. and L.T. Wells. Negotiating third world mineral agreements. Cambridge, Massachusets: Ballinger Press, 1975.

Smith, P.J. "The politics of plenty: Investing natural resource revenues in Alberta and Alaska." *Canadian Public Policy* Vol. 17 [2] (1991): 139-154.

Snape, R.H. "Effects of mineral development on the economy." *Australian Journal of Agricultural Economics* Vol. 21 (1977): 147-155.

Solow, R. "Intergenerational equity." *Review of Economic Studies Symposium on the economics of exhaustible resources* Vol. (1974): 29-45.

Sub-committee of the intergovernmental working group on the mining industry. Report on native participation in mining, phase I. Department of Indian and Northern Affairs, Ottawa, 1990.

Sub-committee of the intergovernmental working group on the mining industry. Report on native participation in mining, phase II: It can be done. Department of Indian and Northern Affairs, Ottawa, 1991.

Thomassen, B. The Black Angel lead-zinc mine 1973-90. Geological Survey of Greenland, Report no. 152. Copenhagen, 1991.

Todaro, M.P. Economic development in the third world. London: Longman, 1989.

Topp, N.H. Kryolitindistries Historie 1847-1990. Copenhagen: Kryolitselskabet Øresund, 1990.

Tsamenyi, B.M. Review of the Tasmanian Mining Act, 1929. Tasmania Department of Resources and Energy, 1989. Research Paper

Tussing, A. R. "An economic overview of economic disposition systems." In Public disposition of natural resources, ed. N. Banks and J.O. Saunders. p. 19-31. Calgary: Canadian Institute of Resources Law, 1984.

Walrond, G.W. and R. Kumar. Options for developing countries in mining development. London: Macmillan, 1986.

Warhurst, A. Environmental management in mining and mineral processing in developing countries: Enterprise behaviour and national policies. Science Policy Research Unit, University of Sussex, 1991.

Warhurst, A. "Environmental management in mining and mineral processing in developing countries." *Natural Resources Forum* Vol. 16 [1] (1992): 39-48.

Westerlund, N.H. Grønlands økonomi ved korsvejen. Nuuk: Pilersuiffik, 1988.

Wiggins, S.N. and G.D. Liebcap. "Oil field unitization: Contractual failure in the prescence of imperfect competition." *American Economic Review* Vol. 75 [3] (1985): 368-385.

Wilson, J. "Taxing mineral resource projects Papua New Guinea, Indonesia and the Philippines." *Resources Policy* Vol. 10 [4] (1984): 251-262.

Wojciechowski, M.J. Eastern Arctic study case study series: The Nanisivik Mine. Kingston, Ontario: Center for Resource Studies, 1982.

World Commission on Environment and Development. Our common future. Oxford: Oxford University Press, 1987.

Mining Legislation

Mining laws and regulations referred to, or used in the text. Titles in Danish are also given intranslation.

Australia

Northen Territory of Australia Mining Act (as in force 1st June, 1990).
Northen Territory of Australia Mining Regulations (as in force 31st May, 1989).
Northen Territory of Australia Mine Management Act 1990 (no. 37 of 1990).
Northen Territory of Australia Mineral Royalty Act (as in force 25th June 1987).

Tasmania Mining Act 1929 (as in force January 1989).

Western Australia Mining Act 1978 (as in force at 28th August 1990).
Western Australia Mining Regulations 1982 (as in force at 16th November 1990).

Canada

British Columbia Mines Act, Statutes of British Columbia 1989, chapter 56.
British Columbia Mineral Tenure Act, Statutes of British Columbia 1989, chapter 5 (consolidation November 8, 1991).
British Columbia Mineral Tenure Act Regulation, British Columbia Regulation 297/88 (consolidation April 16 1992).
British Columbia Mineral Development Assesment Act, Statutes of British Columbia 1989, chapter 55 as in force January 1992).
Resource Management Branch. Health, safety and reclamation code for mines in British Columbia. Victoria, B.C.: Ministry of Energy, Mines and Petroleum Resources, 1992.

Ontario Mining Act, Revised Statutes of Ontario, chapter M14 (consolidation January 1992).
Ontario Regulation 116/91, Assessment Work (consolidation January 1992).
Ontario Regulation 115/91, Claims Staking (consolidation January 1992).
Ontario Regulation 114/91, Mine Development and Closure (consolidation January 1992).
Ontario Ministry of Northern Development and Mines. Rehabilitation of mines guidelines for proponents. Government of Ontario, 1992.

Greenland/Denmark

Kgl. Anordning om Udnyttelse af Råstoffer i Grønlands Jordbund. 27. April 1935, Nr. 153. *(Royal Proclamation on use of Raw Material in the Soil of Greenland).*

Lov om mineralske råstoffer i Grønland. Lov nr. 166 af 12. maj 1965. *(Law on mineral raw materials in Greenland, i.e. 1965 Mineral law).*

Lov om mineralske råstoffer i Grønland. Lov nr. 585 af 29. november 1978. *(Law on mineral raw materials in Greenland, i.e. 1978 Mineral law).*

Lov om etablering af et selskab til varetagelse af kulbrinteaktiviteter i Grønland. Lov nr. 595 af 12. december 1984. *(Law authorizing the establishment of Nunaoil A/S).*

Lov om ændring af lov om etablering af et selskab til varetagelse af kulbrinteaktiviteter i Grønland. Lov nr. 106 af 11. marts 1987. *(Law authorizing expansion of state company participation to non-petroleum projects).*

Bekendtgørelse af lov om mineralske råstoffer m.v. i Grønland. Bekendtgørelse nr. 88, 8. februar 1989. *(consolidation of the 1978 law, with the revenue-sharing clause included).*

Lov om mineralske råstoffer m.v. i Grønland (råstofloven). Lov nr. 335 af. 6. juni 1991. *(Law on mineral raw matrials in Greenlland, i.e. the 1991 Mineral law).*

Danish and Greenlandic Government Documents

Arbejdsgruppen vedrørende kulbrintebeskatning. Kulbrinteskat. Ministry of Taxation, Government of Denmark, 1992.

Det rådgivende udvalg vedrørende Grønlands økonomi. Beretning om den økonomiske udvikling i Grønland 1992. Copenhagen: Government of Denmark, 1993.

Directorate of, Economy. Newsletter no 1. Greenland Home Rule Authority, Nuuk, 1988.

Directorate of, Economy. Newsletter no. 7. Greenland Home Rule Authority, Nuuk, 1992.

Hjemmestyrekommissionen. Hjemmestyre i Grønland. Betænkning afgivet af Kommissionen om Hjemmestyre i Grønland. Betænkning nr. 837. Government of Denmark, 1978

Minelovskommissionen. Betænkning fra Kommissionen vedrørende Minelov for Grønland. Betænkning nr. , Government of Denmark, 1963.

Mineral Resaources Administration for Greenland. "Pressemeddelelse." 1993. (unpublished press release).

Mineral Resources Administration for Greenland. Beretning for Perioden 1. juli 1983-30. juni 1984. Mineral Resources Administration for Greenland, 1984. Annual report

Mineral Resources Administration for Greenland. Beretning for Perioden 1. juli 1984-30. juni 1985. Mineral Resources Administration for Greenland, 1985. Annual report

Mineral Resources Administration for Greenland. Beretning for Perioden 1. juli 1985-30. juni 1986. Mineral Resources Administration for Greenland, 1986. Annual report

Mineral Resources Administration for Greenland. Beretning for Perioden 1. juli 1986-30. juni 1987. Mineral Resources Administration for Greenland, 1987. Annual report

Mineral Resources Administration for Greenland. Beretning for Perioden 1. juli 1987-30. juni 1988. Mineral Resources Administration for Greenland, 1988. Annual report

Mineral Resources Administration for Greenland. Beretning for Perioden 1. juli 1989-30. juni 1990. Mineral Resources Administration for Greenland, 1990a. Annual report

Mineral Resources Administration for Greenland. Rapport fra strategigruppen vedrørende mineralske råstoffer i Grønland. Mineral Resources Administration for Greenland, 1990b. Annual report

Mineral Resources Administration for Greenland. Beretning for Perioden 1. juli 1990-30. juni 1991. Mineral Resources Administration for Greenland, 1991a. Annual report

Mineral Resources Administration for Greenland. "Orientering om landstingets behandling den 15. april af forslag til lov om mineralske råstoffer m.v. i Grønland." Mineral Resources Administration for Greenland. Unpublished MRA document, 1991b.

Mineral Resources Administration for Greenland. Beretning for Perioden 1. juli 1991-30. juni 1992. Mineral Resources Administration for Greenland, 1992a. Annual report

Mineral Resources Administration for Greenland. "Forretningsorden for Fællesrådet vedrørende Mineralske Råstoffer i Grønland." 5. Unpublished MRA document, 1992b.

Mineral Resources Administration for Greenland. "Modeltilladelse med eneret til efterforskning og udnyttelse af kulbrinter for et havområde ud for Vestgrønland syd for 66°N." Unpublished MRA document, 1992c.

Mineral Resources Administration for Greenland. "Principper og procedurer for meddelelse af forundersøgelses-og efterforskningstiladelser vedrørende mineraler i Grønland". Unpublished MRA document, 1992d.

Mineral Resources Administration for Greenland. "Standardvilkår for efterforskningstilladelser vedrørende mineralske råstoffer i Grønland." Unpublished MRA document, 1992e.

Mineral Resources Administration for Greenland. "Standardvilkår for forundersøgelsestilladelser vedrørende mineralske råstoffer i Grønland." Unpublished MRA document, 1992f.

Mineral Resources Administration for Greenland. Beretning for Perioden 1. juli 1992-30. juni 1993. Mineral Resources Administration for Greenland, 1993a. Annual report

Mineral Resources Administration for Greenland. "Orientering om lovgivning i Grønlands Landsting og i Folketinget om udvidelse af rammerne for Nunaoil A/S's virksomhed." Unpublished MRA document , 1993b.
Mineral Resources Administration for Greenland. "Orientering om Grønlands Hjemmestyres planer om finansiering af luftbårne geofysiske undersøgelser i Grønland med henblik på fremme af efterforskning på mineralområdet" Unpublished MRA document , 1993c.

Ministry of Finance. Forslag til tillægsbevillingslov 1986 *(Supplementary budget proposal).* Government of Denmark, 1986.

Ministry of Finance. Forslag til tillægsbevillingslov 1990 *(Supplementary budget proposal).* Government of Denmark, 1990.

Ministry of Finance. Forslag til tillægsbevillingslov 1991 *(Supplementary budget proposal).* Government of Denmark, 1991.

Ministry of Finance. Finanslovforslag 1993 *(Budget proposal)*. Government of Denmark, 1993.

Personal communications

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