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RESEARCH ON MINERALS FOR PHILIPPINE DEVELOPMENT  
PLANNING: A SURVEY

by

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The views expressed in this study are those of the author and do not necessarily reflect those of the Institute.

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## INTRODUCTION

### GENERAL STATEMENTS

The mining industry is one of the few industries that fuel the engine of economic and social development of the country. Like the sugar and coconut industries it earns foreign exchange which the country transforms into self-regenerating industrial and social capital, along with a host of other benefits, including government revenues. Unlike the coconut and sugar industries it is not encumbered by the problem of tenancy and does not compete for the use of premium agricultural lands. It therefore has the potential of further increasing its contributions to national development with the least strain being experienced by other sectors of society. Then we can ask if this industry can still enhance its contributions to national welfare, and if so, how can it be made to increase its contribution? Can government policy be used to boost the industry's contribution? Will research help the industry? This work therefore aims to assess mineral related researches with the view of identifying areas in which researches or related activities may be necessary in order to enhance the contribution of the industry to national development.

This work consists of two steps. First, the basic concepts and principles of the mineral industry are set down to make it more intelligible and at the same time map out areas in which researches of consequence have been done elsewhere. Second, using researches done in other parts of the world as reference, then researches done domestically are assessed to determine what they have covered and what they have not, concluding with a set of recommendations for future research.

Although minerals include categories like fuel, metallics and non metallics this work focuses only on metallics due to time constraints. However most principles applicable to one are also applicable to the other.

#### Classification of Minerals

Natural resources may be broadly classified into flow and fund resources (Reynolds, J. et. al. 1974, 116-127). Flow resources consist of those inexhaustible resources whose present supplies are not diminished by previous use; they are either nonstorable or storable such as sunlight and rain water. On the other hand, fund resources consist of exhaustible resources which may be either renewable or non-renewable as exemplified by forests and copper deposits.

Most mineral resources belong to the class of nonrenewable resources although some mineral resources (e.g. magnesium from sea water and nitrogen from the air) are really renewable. The term "mineral" is used here in the legal or commercial sense rather than in the strict mineralogical definition. For instance the Philippine Mineral Resources Development Decree of 1974 (Pinpin, F.D. p. 3) defined minerals as "...all naturally occurring inorganic substances in solid, liquid or any intermediate state including coal. Soil which supports organic life, sand and gravel, guano, petroleum, geothermal energy and natural gas are included in this term..."

Although minerals have been classified in many ways depending on objectives, they may be classified for the present purpose into fuels, metals and nonmetals.

Minerals which serve as source of energy are called fuel minerals. Fossil fuels which are stored solar energy such as petroleum, natural gas, coal, lignite, peat, shale oil and tar sands belong to this group. Minerals which contain radioactive element such as uranium and thorium are also fuels. Heat stored in the rocks (geothermal energy) are also classified as mineral fuel.

The common sources of metals are called metallic minerals. The metals may be divided into precious and base metals. Gold, silver

Table 1

## CLASSIFICATION OF MINERAL

Fuels	-	Petroleum, natural gas, coals, lignite, peat, uranium, thorium Shale oil, Tar sands Geothermal heat
Metals	-	Precious, gold, silver, platinum Base metals - ferrous or ferro-alloys, like iron, chromium, nickel, manganese; nonferrous like copper, lead, zinc, tin, and mercury
Non-metals or Industrial minerals	-	Construction materials - cement, limestone, adobe, gravel and sand, Chemicals - phosphates, potash, industrial salt, sulfuric acid Ceramics - clay, dolomite, chromite Abrasives - diamond, corundum, garnet characterized by: (a) high bulk, low unit cost (b) market demanding specifications (c) specialized processing and testing techniques (d) importance of customer service (e) interaction of growth of industrial minerals with growth of urban areas

and platinum are precious metals. On the other hand base metals may still be divided into ferrous and non-ferrous. Ferrous metals consist of iron and other metals that alloy with iron in steel making such as manganese, nickel and chromium while the other metals like copper, lead, zinc, tin and mercury are nonferrous.

Nonmetallic minerals is a large group of minerals which are useful neither as a source of energy nor of specific element. They are useful in various industries for a great variety of functions. They may serve as construction materials such as cement, gravel and sand, marble and adobe stone. Phosphates, potash, industrial salt, limestone and sulfur are of course vital to the chemical industries. Clays, dolomite, and chromite, among others, are important ceramics raw materials. Abrasives like diamond corundum and garnet are indispensable to many industries. These nonmetallic minerals are characterized by high bulk and low unit value. Nonmetallic minerals are closely tied to the growth of urban areas and of industries. In fact "To a very large extent industrial growth means growth of the industrial mineral industry." (Toombs, R.B. and Andrews, P.W. p. 42-51)

This work focuses mainly on metallic minerals since the mineral industry in the country deal mainly with metallic minerals.

Time and resource constraints, in addition to the institutional separation of fuel and metallic mineral industries, forces this work to concentrate on the metallic minerals.

Apart from the classification of minerals a discussion of the various stages of the mineral industry could also provide important insight into the nature and problems of the mineral industry.

#### Stages of the Mineral Industry

Valuable insight into the behavior of the mineral industry can be obtained by examining the various stages of the mineral industry. Given any specific objective, policy need be directed only to a specific stage rather than to all stages with greater efficiency and economy. Furthermore each stage can be regarded as a production process with distinct inputs and outputs.

Different writers recognize slightly different stages, no doubt because of their varying experiences. A writer from a developing country (e.g. Santillan, T., p. 150-152) usually emphasizes the exploration, development, mining and milling, concentrating, and marketing stages whereas one from a developed country (e.g. see Gluschke, W. et.al., 1979, p. 2) may not even mention exploration as a distinct stage but instead includes semi-fabrication and fabrication

stages, a rather extreme view. This section presents all the stages of a fully developed mineral industry so that some of them may be missing in any specific country. A summary of the stages of mining are given in Table 2.

Exploration stage is very important in any mineral industry. It consists of all activities essential to the discovery and delineation of an economically promising resource including the establishment of legal rights. Prospecting, geological mapping, geochemical and geophysical surveys and even test drilling, tunneling and test pitting to establish the existence of a resource which is promising enough in terms of its quality and size are the usual activities under this stage. The much ballyhooed risks of the mineral industry are encountered in this stage. Activities under this stage may grade into the development and infrastructure stage.

Development of a mineral deposit consists mainly of transforming resources discovered and located during the exploration stage into reserves, the basis of future production. Expensive systematic drilling, tunneling, pitting and sampling of the deposit to establish its magnitude and quality within the requirements of sound engineering practice and bankability are done in this stage. But even if a large and sufficiently high grade deposit is established economic recover-

Table 2

STAGES OF THE MINERAL INDUSTRY  
(Modified After T. Santillan and W. Gluschke)

## EXPLORATION STAGE

Prospecting; Laying down of Claims  
Execution of Mining Lease, Contracts  
Detailed Geologic Survey, Mapping  
Preliminary drilling, sampling, tunneling.

## DEVELOPMENT STAGE

Establishment of Mineral Reserves through systematic drilling,  
tunneling, sampling  
Preparation of Reserves for Extraction  
Technical, Economic and Financial Feasibility Studies  
Pilot Plant Construction (Optional)

## MINING STAGE

Extraction of Ore from the ground either for feeding into the  
mills or for shipment to consumer depending on quality  
of ore

## MILLING AND CONCENTRATING STAGE

For crushing, and grinding of the ore and for separating  
undesirable minerals to produce a mixture containing  
sufficient amount of desirable minerals for economic  
extraction. End product is a concentrate which may  
be shipped to a smelter, the consumer of concentrates.  
(For copper concentrates, copper content may be 25-30%).

## MARKETING AND TRANSPORTATION STAGE

Transporting to market and sales to consumers of marketable  
product which may be direct shipping ores, concentrates,  
crude metal, refined metal, or semi-fabricated metal.

## SMELTING STAGE

Concentrates or direct shipping ore are treated to produce  
impure metal usually not yet ready for use. For copper  
the product at this stage is called blister copper.

## REFINING STAGE

Crude or impure metal is treated at this stage to produce what  
may be transformed into products which may be used as raw  
materials for manufacturing. In copper, 99.9% pure cathode  
copper may be produced at this stage.

## SEMIFABRICATING STAGE

Refined metal is transformed into semi-finished products such as  
sheets, tubes, bars and wires for copper and sheets,  
billets, shapes, bars and coils for iron and steel.

## FABRICATING STAGE

Semifabricated metals are manufactured into products like cars,  
appliances, machineries, etc.

ability has to be proven yet by treating large tonnages in pilot plants. Due to the large investments needed a feasibility study, both technical and financial, must be made to assess the effects of various factors such as tonnage, grade, distance to nearest road, distance to market, costs, taxes and fluctuating prices, upon the profitability of the deposit. Given that the project is feasible within reasonable limits, then necessary infrastructures such as roads, bridges, ports, power lines, water system, township, school, hospital and the like may be constructed. Thus the development and infrastructure stage consists of investments in producing at least a minimum size and grade of reserves and in activities and facilities necessary for extracting reserves, and marketing the products. This stage is thus risky, time consuming and capital intensive. Expenditures in the tens of million pesos may be incurred here only to find out later that the project is unprofitable.

After the blocking of adequate ore reserves facilities for ore extraction, milling and concentration must be put up for the mining and milling stage. Very detailed knowledge about the distribution and concentration of the metals must be obtained in order to have adequate control of the product. For underground mines a system of holes and openings are constructed to have access to the ore body and to install the necessary facilities for bringing the ore to the mill,

for ventilation, lighting and blasting. As for open pit mines, power shovels, powerful haulers, along with electrical and water facilities, have to be installed. Of course dynamites and drilling equipment are needed to break up the rocks.

The ores are crushed, and ground to proper sizes in the mill and then passed to the concentrators to remove the undesirable components. For instance, copper ore with 0.5% copper is transformed into a product containing 25-30% copper after passing through the concentrator. Large amount of energy is needed during the crushing and grinding process while tons of expensive chemicals are used during concentration. The output therefore of the mining and milling stage is marketable product, the concentrate, which may be sent to smelters for final extraction of the metal. Most mining operations in the Philippines end at this stage except the nickel of Marinduque Mining and the primary gold mines which continue into the smelting stage.

To be useful, the metal from the concentrates must be extracted and refined in the smelting and refining stage. By applying heat upon the concentrates which are treated with various chemical reagents a crude metal, say 95% pure copper, may be produced. Impurities of silicates, sulfur, gold, silver, iron and others must be removed in the refining stage by employing large amounts of electricity to

produce, say copper with 99.9% purity along with gold, silver and other metal by-products. The metal product of this stage is ready for processing into semi-finished or manufactured products.

The refined metals are therefore sold to semi-fabrication plants which transform them into sheets, strips, bars, rods, tubes, wires, bronze, and brass. These are now ready for fabrication into final products such as automobiles, machines appliances and the like.

The marketing stage is therefore the end of every mineral industry because the usual objective of mining is to transform the ore into cash. What may be sold are direct smelting ores (very high grade), concentrates, crude metal, refined metal or semi-processed metal, depending on the quality of the ore or on the degree of vertical integration of the firm. This means that marketing may follow after any of the following stages: mining, milling, smelting, refining, semi-fabricating.

The nature of the product sold by the mineral industry has profound effects on the value of sales, transportation costs, magnitude of required investments and social benefits and costs. This is so because large investments are involved in each of the stages past the exploration. In addition the value of the products increases as more

processing are done while the cost of transporting to market diminishes. Consequently more foreign exchange, taxes and employment are generated as more stages are traversed by the industry.

Closely related to the stage of the mineral industry are its characteristics which may provide additional insight into the behavior of the industry.

#### Characteristics of the Mineral Industry

The mineral industry is said to be area specific, risky, capital intensive, exhaustible and associated with long lead time.

#### Exhaustibility

The fact that minerals are finite, exhaustible or wasting assets generates concern over their future availability and raises the question of equity of allocation within and between generations. Two views on exhaustion - the physical and economic - are helpful in understanding this problem.

Under the physical view it is held that since the mineral supply is finite and since demand is increasing exponentially then supply would have to be depleted sooner or later. Applied to the

existing reserves of minerals (and energy) Meadows, Donella et.al. (1972) painted a very grim picture of future mineral supply.

For instance, at 1972-1974 rate of consumption only, the reserves of a few minerals will last a hundred years or more at zero growth rate; if consumption grows at 5.0% per annum, only potash could last for a hundred years while only three (out of 30) would last about fifty years; at 10% annual growth of consumption only potash will last more than 50 years while the remaining 29 minerals will have their reserves consumed for less than 40 years, many in less than 20 years.

When the pressure of exponential growth of consumption was applied to all the metals contained in the accessible portion of the earth's crust down to three km, regardless of whether they can be economically extracted or not (resource base), it was discovered that at 5.0% growth rate most metals will be exhausted in about 300 years, and at 10.0% growth rate most metals could not last for 200 years (Tilton, J.E., 1977, p. 12-13).

Such a bleak scenario of mineral is questioned on several counts. First, reserves are very conservative estimates of mineral supply since they measure only what are known economic deposits. However resource base is perhaps an upper limit for available minerals.

Second, the effect of technology either on supply or demand is not taken into account since it is assumed to remain constant despite the pressure of increasing scarcity. Third, the effect of recycling is not considered. Finally there is a body of evidence indicating that the growth in per capita consumption decreases as certain threshold per capita income is approached beyond which per capita consumption declines (intensity of use hypothesis).

The economic view of exhaustion stipulates that even if physical resources remain infinite the real costs of finding and processing them will rise as producers are forced to turn to poorer deposits hence forcing society to curtail its mineral demand. This argument implies that economic exhaustion (i.e. when demand is zero) will set in long before physical exhaustion is felt. When this view was tested empirically for 1870-1957 it was discovered that the real costs of producing minerals decline from 210 index points in 1870 to 47 in 1957. This phenomenal cost reduction was ascribed to new discoveries and technological innovations. (Barnett, H. and Morse, C., 1963; see also Tilton, J.E., 1977, p. 11). Of course, there is no assurance that technology and new discoveries will continue to decrease production costs in the future.

### Risks

It is common knowledge that mining is a risky business. But in what sense is mining riskier than other business? Like other business it suffers from the difficulty of predicting costs and prices perhaps to a greater extent, due to greater volatility of prices, as they are affected by global factors beyond control of local authorities, such as inflation and energy prices spiral (economic risks). Like other business it faces the danger of defaulting payment on its loans because costs and prices did not turn out as expected, perhaps to a greater degree because of the long lag time between the decision to produce and actual production, in addition to the considerably larger amounts involved (financial risks). It is also true that accidents are more frequent and more serious in mining operations than in most other industries because of the generally hazardous conditions obtaining in a mine where cave-ins, explosions, and fires, among others, could cause major disasters (operational risk). (See Tilton, J.E., 1977, p. 28-30; CRC, 1973, p. 6-7)

But there are risks which are indeed unique to the mineral industry. These risks should be carefully examined to appreciate the behavior of the mineral industry. Two are given below which are based on the discussion by Brooks, D. (1976), and Armstrong, W. (1974).

First, the raw materials for mining are mainly ore reserves. But at best reserves can only be estimated and are therefore always associated with errors. The best estimated reserves usually differ from the true value by about 20% (McKinstry, 1948) so that very expensive plants and equipment may be installed only to run out of ores before investments are recovered. Greater uncertainties, however, are associated in the search for ore bodies (exploration stage) which may be developed later into reserves.

Study of the operations of large mining companies with high level of technical expertise indicates the uncertainties and costs associated with exploration (Morgan, D.A., 1970, p. 305-324).

- (1) In a terrain comparable to the Basin Range Province of the USA the chance of discovering a property that will yield a total revenue of \$100 million was roughly 1 in 250, and for a deposit ten times as large the odds were 1 in 1000.
- (2) Study based on 4865 properties in Canada and 235 mining districts in the USA indicated that the chance of discovering a deposit of \$50 million or larger was about 1-2%.
- (3) A company spending \$1,500,000 to \$3,000,000 per year in mineral exploration and research should have a better than 50% chance of success in exploring in many different geological environments within say 6-10 years.

- (4) Large companies generally spend 3-20% (generally less than 10%) of their cash flow before tax on exploration and research but small mining firms spend more in their effort to survive and improve their position.
- (5) On the average at 40% tax rate and 9% interest the present value of exploration costs at the point of decision to produce is \$31 million while the cost of development and construction amount to \$55 million.

Experiences in the Philippines support the findings above.

For instance, it was reported that "out of 1000 exploration ventures initiated only 7 proceeded to production, and of these only 2 became profitable." Again Mr. Henry Brimo cited that "... From 1933 to 1938 at least 800 Philippine mining companies probably examined at least 8000 prospects (a conservative estimate indeed!). Only 42 reached the production stage, 4 are still operating though only 2 are profitable." These data indicate that exploration risks incurred in the Philippines are higher than those reported for high caliber large mining companies abroad, a situation that we should expect since very few local firms, if at all, are at par with the best in the world.

As the above data indicate, the high risks associated with the exploration and development stages indeed set the mineral industry from the rest of other industries.

Another risk that is particularly patent to the mineral and other natural resource industries may be called political risks. What these risks are, or what they consist of, may be gleaned from the words of an international economist who has studied the African mineral industries for a long time (Armstrong, Winifred, 1974).

...Western and Japanese mining companies are reluctant to put their money in Africa for fear the rules will be changed soon thereafter and they will either lose their investments or make it back too slowly with too little control...

...And indeed the trend toward African government to acquire shares and even majority ownership in heretofore foreign owned companies-mineral and petroleum being prime targets-began in the late 1960s. At least 20 African countries have nationalized one or more firms. A recently published United Nations Survey showed a body count of 875 companies nationalized in 62 countries around the world since 1960...

The risks, in essence, consists of changes in rules governing mineral investments. This is disturbing because the feasibility of a project must be evaluated according to a set of rules; if they change before the life of the project expired then its profitability may be in question. Therefore frequent changes in rules affecting the mineral industries is repugnant both to foreign and local investors. For instance, representatives of the local mining industry state that

. .the stability of government policies was one if not the most important factor necessary for long run development of the mining industry. The ad hoc changes in government regulations and policies have adversely affected all attempts by mining companies to plan long-range, upsetting profitability projections, financing schemes and foreign investment calculations...(CRAI, 1978, p. 2).

What makes the mineral industry particularly susceptible to political risks is the perception that minerals are part of the national heritage that are exhaustible and non-renewable and therefore the people must extract from them maximum welfare possible. Perception of welfare or what is good to the people frequently changes and hence rules intended to safeguard national welfare do likewise. The adverse effect of abrupt policy changes in many countries resulting in drastic reduction in production and reserves are well documented (Moran, T., 1973; International Monetary Fund, 1973; Tilton, F.E., 1977).

#### Capital Intensity and Long Lead Time

Discussion of the various stages of the mineral industry suggest that the mineral industry requires large investments. Although the exploration stage is quite expensive, development, smelting and refining stages are all the more expensive. The capital intensity in the mineral industry is strongly indicated by the projects listed below.

Iron Mine and Pelletizing Plant in Fire Lake, Quebec  
(on stream in 1977) - \$510 million

Cerro Colorado Copper Project in Panama Mining up to  
concentrate (1977) - \$800 million

Dizon Gold-Copper Project in Zambales, P.P., Mining  
to concentrates (1979) - \$100 million

PASAR Copper Smelter Project in Isabel, Leyte, R.P.  
(1980) - \$350 million

Aluminum Smelter Complex, Isabel Leyte, R.P. (1980)  
\$450 million

The capital intensity of the mineral industry becomes more obvious if we realize that on the average it takes a ₱55,000 investments in fixed assets to create a job in the mineral industry against the ₱15,000 per worker in the other industries. (CRC, 1975, p. 68)

Mineral projects being large and complex take long time to plan, finance and construct. Large projects like the Toquepala Copper Project in Peru and Cerro Colorado in Panama took at least 10 years before full production was attained. Many copper mines in the Philippines like Marcopper, Sto. Nino of Baguio Gold, Surigao, Samar, Batong Buhay, Dizon and Bobok of Benguet Corporation took about 10 years to develop before they became productive (CRC, 1979, p. 7).

### Location Specific

Another important characteristic of the mineral industry is that the mine can only be built where the ore occurs. This means that most ...mining operations are generally located in hinterlands which are usually inaccessible via the public roads..." (CRC, 1973, p. 1) because ores are generally found in mountains which are far removed from well-established settlements. Consequently, the mining firms have to build roads to connect to the nearest existing government roads, along with townships, hospitals, schools, power and water system and recreational facilities, among others, to induce workers to stay. Hence two important conclusions may be deduced from the location of mines in the hinterlands. First, it is obvious that mining firms spend a large amount on what may be called social infrastructures and amenities which are not directly connected with production. Second, by providing a nucleus of economic and social activities in an area where they did not exist before and by linking it with roads to more developed communities nearby, a mining firm serves as an agent of rural or country side development, perhaps unwittingly. If such activities will be merged with the government's development plan in a given mineral district more profound and lasting changes may be achieved.

## BASIC CONCEPTS AND PRINCIPLES

This chapter covers the basic concepts and principles relating to mineral demand and supply. Factors affecting demand are first discussed, followed by a more extensive discussion of supply concepts and theories governing their behavior. Emphasis is given on the supply aspect since minerals differ from other commodities more on the supply than on the demand side.

### Mineral Demand

Several concepts are important in understanding mineral demand. They are the market, prices, concentration, substitution, intensity of use and cyclical volatility.

### Market and Prices

Minerals are international commodities so that they are sold in the world market at prices which are related by transportation and handling costs. Of the total value of commodities moving in world trade in the early 1960's, 26 percent was mineral. About 40 percent of these minerals originate from developing countries which are exported to industrialized countries. Minerals sold by developing countries are usually in the form of crudely processed ores or metals

whereas exports from developed countries are more highly processed. In bulk and value, petroleum is dominant, followed by iron ore and steel, bauxite and alumina, and the traditional high valued nonferrous metals such as copper, tin, zinc, lead, gold and silver. (McCaskill, J.C., 1975, p. 73-123)

Much of the minerals moving in international trade are bound either by long term or short term contracts. Short term contracts are negotiated every year while long term contracts are made to last for more than a year, on the average for about five years. Due to many uncertainties in the market frequent renegotiations of the terms of contract, particularly prices and volumes, are made. (Santos, T., 1976)

A smaller volume of refined metals is sold in commodities markets such as the London Metal Exchange (LME) and the New York Commodity Exchange (COMEX). These markets are essentially competitive, and hence their prices reflect the demand-supply imbalances in the market even if they represent but a small volume (10-20%) of the metals. Metals like gold, silver, copper, tin, lead, and zinc are traded in these exchanges. Another type of market exists in the United States wherein prices are administered by producers and are set to reflect the more stable long term movement of prices. (Gluschke, et.al., 1979, p. 9; Tilton, J.E., 1977).

Prices in the various markets cited above perform functions more than just pricing the small volume of metals sold in them. They are used as references for pricing the greater volume of metals that are bound in short and long term contracts

#### Concentration

Prices are affected by the degree of monopoly in the market. High degree of control of supply by few producers (consumers) could give them the power to dictate prices. Studies on the concentration of production indicate a large number of minerals are organized along oligopoly lines; for instance four biggest producers accounted for 99 percent of platinum, 82 percent of nickel, 80 percent of phosphates, 73 percent of chromite, 86 percent of cobalt, 60 percent of copper and 48 percent of iron ore. Similarly oligopolistic situation obtains in the buyer's market. Notwithstanding the high degree of concentration, it appears that no dominant producer or consumer who could dictate prices exists (Johnson, C J., 1976, p. 30-34; Gluschke, 1979).

### Substitution

The demand for minerals derives from the demand for the goods and services which are produced out of them. For instance copper is demanded because it transmits electricity or messages efficiently; there is no demand for copper per se. In short, any material like a mineral is demanded for the function it serves in a product or process. It is for this reason that substitution is universal among minerals. Aluminum substitutes for copper in electrical transmission just as aluminum and plastics substitute for steel in car manufacture and structural constructions. Aside from the substitution of materials in the same product or process, a product or process may be replaced by a radically different means of achieving the function it performs such as the transmission of long distance messages by satellite rather than underground cables. The first type may be called material substitution while the second may be called functional substitution.

Substitution is important because the use of relatively abundant material in place of increasingly scarce materials help offset and may even postpone indefinitely the tendency for real material costs to rise due to depletion. Since substitution plays a role in growth of material demand it has to be considered in forecasting future requirements. Factors affecting substitution, among

others, are relative prices, government regulation, consumer preferences, technological innovations and product competition. (J.E. Tilton, 1979)

### Intensity of Use

Intensity of use refers to the material cost of producing a unit of national product. It may be defined in terms, say, of kilograms of copper consumed to produce a dollar of GNP. Defined in this fashion, intensity of use describes an inverted U-shaped locus when plotted against per capita income. This is called the 'law' of materials demand. Such behavior reflects the changing structure of a nation's economy. In the early stages of a country's development rapidly increasing use of minerals take place as infrastructures are built such as roads, bridges, buildings and heavy industries, dams and power plants, among others. As mature stages of economic growth is approached, the rate of consumption of materials diminishes until a maximum level is reached, thus economic activities increasingly focused on less material consuming service activities. (Malenbaum, W, 1975)

### Cyclical Volatility

Many difficulties, both of mineral producers and consumers, are rooted in the wide and unpredictable fluctuations of mineral demand and prices, a phenomenon we call cyclical volatility. Among the important factors affecting it are low short run price elasticities of supply and demand, and large income elasticities. (J.E. Tilton, 1977)

Minerals have low short run price elasticity of supply. As long as excess capacity exists mineral supply is responsive to price changes. However, as full capacity is approached, even very large price increases may not be effective in eliciting substantial increases in production since a long time intervenes between the decision to produce and actual production. Similarly, the demand for minerals does not respond to price changes well because users have fixed plant capacities which require years to expand. Even if substitutes are available at appropriate prices, existing facilities will not be scrapped out so long as variable costs can be recovered. Or at the least substantial costs and time are involved in retooling and retraining workers in order to use a substitute material.

On the other hand, as economic activities expand the demand for capital and durable goods into which minerals are made expand. During contractionary period, the demand for capital and durable goods likewise decline. The demand curves for minerals, therefore, shift frequently in response to the changing phases of the business cycle, thus accounting for the cyclical volatility of demand and prices.

The amplitude of the fluctuation in demand and prices is exacerbated by a number of factors. These are, the increasing synchronization of the business cycles in the developed countries, speculation and stockpiling activities. The effect of the first is self-explanatory but some explanation may be needed for the last two.

When mineral prices are declining, fabricators anticipate further decline so that they draw from existing stocks instead of buying in the market, hoping to buy at a later time. Stocking when supply is abundant does not make sense since no advantage can be gained while it entails costs. But as prices move upward, consumers rush to the market to buy their current requirements as they stock up too for future use. Although fabricators are more concerned with lowering costs than making profits their behavior parallel that of the true speculators who try to make profits by "selling short" when prices are moving down and "buying long" when prices are moving up.

Certain governments stockpile a number of materials to avoid the adverse effect of shortages or embargoes on their military preparedness and economics. Since the volumes involved are substantial, the stockpiling activities could stimulate prices to move upwards. However, when the stockpiling authorities withdraw from the market, that portion of supply which came about in response to stockpiling will remain unsold and cause a glut in the market forcing prices to move down.

#### STOCK CONCEPTS OF MINERAL SUPPLY (OR LONGRUN MINERAL SUPPLY)

##### Resource Concepts

How much mineral may be available in a given place and time is certainly a crucial question in mineral economics. But this brings us to the more fundamental question of how much mineral stocks do we really have in the ground. Alternatively, we can ask: what are the measures of mineral stocks? Ultimately, therefore, it is necessary to clarify the commonly misunderstood concepts of mineral stocks, viz., resources and resource base. The following discussions are based on the paper by Brooks, D. (1976) which reviewed extensively the concepts as used by different authors.

The various mineral stock concepts may be defined within two important dimensions. The first is the cost-price (cost/price) dimension which captures the effects of factors that influence the prices or the costs of producing minerals. Another dimension indicates the degree of geologic certainty (probability) one can attach to estimates of mineral stocks. The latter dimension implies that mineral stock concepts can not be measured absolutely; they can only be estimated. Considering the volatility of mineral prices and the diversity of factors affecting costs, one realizes that mineral stocks estimates are changeable and that they are not only subject to the influence of physico-chemical forces but are highly susceptible, too, to social, political and economic factors.

#### Reserves and Resources

On the basis of increasing cost-price ratio mineral stocks may be classified into reserves, submarginal resources, and latent resources. Reserves consists of mineral stocks which are economically exploitable under existing technologic, economic, social and political conditions. A group of mineral deposits, submarginal resources, may not be economic to extract under present conditions but may become economic if some improvement in technological, economic, social or political conditions come about. Very substantial improve-

ment in cost-price ratio brought about by technological innovations, more favorable prices, or more stable socio-political conditions may transform latent resources into reserves. Note that latent resources may move upward to submarginal resources or even to reserves; and conversely, reserves may move downward to submarginal or latent resource category depending on the cost-price situations.

#### Identified and Undiscovered Resources

Using the geologic dimension reserves, submarginal resources and latent resources may be divided into identified and discovered. Certainty of knowledge about the mineral stock is high for the identified resources but low for the undiscovered. Minerals under undiscovered category may be elevated to identified by exploration, i.e. greater geologic certainty about mineral stocks can be had by investments in exploration

#### Resource Base

Finally, another important mineral stock concept not definable within the cost-price-geologic dimension must be recognized. This is the resource base. This concept disregards the economic dimension but is mainly based on technological and physico-chemical factors. It reflects the upper limit of a given resource based on existing and

Table 3 -- Classes of Mineral Reserve and Resource Estimates<sup>a</sup>

Quality of the Resource (Cost-Price Dimension)	Degrees of Knowledge About the Resource (Geologic Dimension)			
	In Known Deposits or Districts			In Undiscovered Districts
	Identified Reserves			Undiscovered
	Measured Reserves	Indicated Reserves	Inferred Reserves	Potential Reserves
Recoverable under Market and Technologic Conditions	Proved Reserves	Probable Reserves	Possible Reserves	Reserves
	Developed Reserves	Undeveloped Reserves		Reserves
Recoverable at prices up to 2 times those prevailing now or with comparable advance in technology	Identified submarginal resources <sup>b</sup>			Undiscovered submarginal resources
Recoverable at prices 2 to 10 times those prevailing now or with comparable advance in technology	Identified latent resources <sup>b</sup>			Undiscovered latent resources
Total	Total Identified resources			Undiscovered resources
				Total potent resources

<sup>a</sup> The block of resources described by these estimates accounts for only a part, generally a small part, of the resource base.

<sup>b</sup> The terms measured, indicated and inferred may also be applied to known submarginal and latent resources where knowledge of them is sufficiently detailed to warrant differentiation in the degree of certainty of the estimates.

foreseeable technologies. One may talk about a country's copper, gold, iron, coal or petroleum resource base. The Philippine copper resource base may be defined, for example, as all the copper metal contained in the rocks within the upper three kilometer zone of the earth's crust under the country's territory. The three kilometer zone is set by current technology and may change depending on the nature of the mineral (whether liquid or solid). The significance, therefore, of the resource base is that it gives the policy maker a rough idea of the maximum amount of a given mineral that could become available under the most favorable conditions.

There are other factors that influence the nature of a mineral stock and which may become very important locally. For instance, even if a large copper deposit of a given grade occurs in a locality, it could either be classified as reserve, submarginal resource, or latent resource depending on how much of the metal is recoverable, or whether it is located in an inaccessible place or whether it contains excessive deleterious impurities.

## Estimating Resources along the Geological Dimension

Some of the methods for measuring reserves, resources and resource base are presented under this section with the aim of further clarifying the meaning of such concepts and identifying some of the important variables that affect them.

Reserves are either identified or undiscovered. Identified resources may still be subdivided into categories like measured, indicated and inferred. Definitions of various categories of identified reserves are given below (Brooks, D., 1976, p. 145).

"Measured reserves are those for which tonnage is computed from dimensions revealed in outcrops, trenches, working and drill holes and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling and measurement are spaced so closely and the geologic character is so well defined that size, shape, and mineral content are well established. The computed grade and tonnage are judged to be accurate within limits which are stated, and no such limit is judged to be different from the computed tonnage or grade by more than 20 percent."

"Indicated reserves," on the other hand, "are those for which tonnage and grade are computed partly from specific measurements, samples or production data and partly from projection for reasonable distance on geologic evidence. The sampling are either too widely or inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout."

Finally "inferred reserves are those for which quantitative estimates are based largely on broad knowledge for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition of which there is geologic evidence..."

The measured - indicated - inferred reserves terminology indicate clearly that as precision of reserve estimate increases investments in tunneling, trenching, drilling, and sampling proportionately increases. Because of the large expense associated with developing reserves, particularly measured (or its equivalent) reserves, the mineral producers tend to develop just the minimum amount to justify a given capital outlay. Hence reserves are very conservative estimates of what may be available. Reserve terminologies parallel to measured - indicated - inferred are in use particularly by mining organizations. Methods of estimating identified reserves are well-developed and presented in books on mining, geology or mine valuation.

#### Undiscovered Reserves

To some writers (McKelvey, V., 1973, 67-82) it is important to distinguish between undiscovered resources located in known districts and resources in unknown districts. The term hypothetical and speculative resources are applied to resources in known and unknown mineral districts, respectively. Many geologists prefer the use of these terms. However, in the scheme we are presenting, undiscovered reserves are used to designate unknown resources which can be extracted at a profit under existing conditions. How these unknown

reserves (resources) are measured without being discovered are illustrated below. Two examples are considered, geographic analogy and statistical distribution techniques.

#### Geographic Analogy of McKelney

This method is suitable for investigating large areas. A relationship of the following type is assumed

$$(1) \quad R = k A$$

where  $R$  equals metal reserves in tons;  $A$  equals crustal abundance of a metal expressed in percent, and  $k$  equals a constant equal to  $10^6 - 10^{10}$  for all metals;  $10^9 - 10^{10}$  for old metals; and  $10^6 - 10^9$  for new metals. The constants have been evaluated for areas in which extensive information concerning previous mineral production, current reserves, and metal abundance are available. For a large area of interest, the unknown reserves may be estimated by determining the average concentration of the metal contained in the crust and plugging it in the equation above. This method calls for extensive analysis of the crustal composition of various areas (See Fig. 1).



Multivariate Discriminant Model of  
Harris and Euresty

Unlike the Geographic Analogy, this method yields more precise results even for relatively small areas. It postulates a relation of the following type:

$$(2) \quad R = a_0 + a_1 X_1 + a_2 X_2 + \dots + a_n X_n + E$$

where  $R$  = reserves, say in tons;  $X_1, X_2, \dots, X_n$  are geologic variables such as area of a given rock type, number of fractures per unit area, and so on;  $E$  is stochastic error term, and  $a_1, a_2, \dots, a_n$  are coefficients determined for a known area. The above equation can be used to estimate the unknown reserves in an unknown area (provided it is geologically similar to the control areas) by plugging in the measured values of the geological variables. This technique, therefore, requires the availability of accurate and detailed geologic maps.

#### Measuring Resources Along Cost-Price Dimension

Measurement of resources can be done by extension along the cost/price dimension. In most instances, only identified resources are measured since gathering information on undiscovered resources does not seem warranted by the great expense.

## Resource Inventory Techniques

Ideally, resources may be compiled by indicating how much can be made available at different levels of costs. This requires the resolving of the various characteristics such as location, tonnage, grade and ore to waste ratio into cost. Alternatively, the amount of each metal of interest that may be made available for every additional unit of capital may also be tabulated. In this way reserves, sub-marginal resources and latent resources can be easily determined.

Usual practice, however, consists of identifying certain properties which correlate closely with costs such as grade, ore to waste ratio, and thickness of seam and then tabulating against tonnage. More complete works involve detailed description of the various characteristics of individual deposits for an inventory.

### Grade Tonnage Relation

Finally, a relationship between ore grade and tonnage for certain types of deposits can be used to measure resources. For instance, a version of the so called "Lasky's principle" states that the ore tonnage increases as average grade decreases, that is

$$(3) \quad G = K_1 - K_2 \log R$$

where  $G$  = the average grade;  $K_1$  = highest naturally occurring grade of the deposit;  $K_2$  = modal grade;  $R$  = cumulative tonnage of metal bearing rock. Since given the deposit type for a given metal one can delineate reserves from submarginal and marginal resources, the above relation can be used to measure various types of resources. This technique is said to be an effective tool for planning for any given mine, but more importantly it suggests that the above equation yields a representative description of the total resources of a given metal as it occurs within a given type of ore deposits. This technique has been applied to the assessment of certain copper, phosphate, vanadium, manganese and chromite resources (Brooks, D., 1976, p. 175).

After showing how resources and reserves may be measured, whether they are known or unknown, we may turn to measuring resource base.

#### Resource Base

In order to measure the resource base of any particular country it is essential to have detailed analysis of the concentration and distribution of the various elements in various regions of the crust. Large quantities of elements are known to occur even in the upper

portion of the earth's crust, in the water and in the atmosphere. A few examples may illustrate the need and procedure for measuring the resource base.

#### In Ordinary Rocks

Igneous rocks are known to contain vast amounts of metals. However, the concentration of each metal may vary depending on the nature and location. Hence chemical analysis of the rocks in a given country must be done to estimate the amount of each metal contained in the rocks. For instance, detailed analysis of the Conway Granite in New Hampshire (Brooks, D., 1976, p. 153) indicated the presence of large amount of thorium, among others, which may become an important source of fuel for breeder reactor.

#### In the Ocean

The oceans, like the rocks, are also vast reservoirs of elements. Among the most abundant are chlorine, sodium, magnesium, sulfur and calcium. However, metals like iron, copper, uranium and gold are also present though in much smaller amounts. In fact the oceans are presently the source of virtually inexhaustible sodium, chlorine and magnesium. Hence it is also necessary to have reliable chemical analyses of the various bodies of water in a given locality to deduce its resource base.

### The Atmosphere

Finally, the atmosphere consists of elements in the gaseous forms. Among the abundant elements in the atmosphere and their average proportion are nitrogen (75.52%), oxygen (23.14%), argon (1.29%), and carbon dioxide (0.05%). Other elements are neon, helium, krypton, hydrogen, xenon and radon. Analyses of these elements may also be done for various localities to establish how much of each may be available.

### Mineral Products Without Limitation

It is clear from the preceding section that vast amounts of metals and other elements can be derived from ordinary rocks, sea water and the atmosphere. Elements in sea water and the atmosphere are even being constantly replenished. Hence ordinary rocks, sea water and the atmosphere could become sources of mineral products without limitations. When these resources become economically feasible (as magnesium, sodium, chlorine, oxygen, and nitrogen are already), the cost of producing stock will become negligible. Consequently, exploration as well as exhaustion, may be eliminated.

Extraction of minerals from resources without limit is completely analogous to manufacturing. Decision on the recovery of mineral products will be based largely on plant costs, not natural resource costs.

Resources without limitations set the upper limit on the prices that can be obtained from conventional sources of supply. This can not exceed the cost of extraction from geologically unlimited source for it will be tapped as soon as prices reach a level high enough to make it profitable.

#### Long Run Supply Function of Minerals

Discussions on the stock concepts of minerals can serve as basis for deducing at least the shape of the long run supply of minerals. However, it is important to first explain what short, medium and long run mean.

There are two important elements that determine the time frame of mineral production, namely, the reserves and the mine capacity. Depending on the various characteristics of a mineral deposit such as its size, type or mineral, it is possible to identify certain time horizons during which (1) neither reserves nor mine capacity, or (2) either reserves or mine capacity only; or (3) both

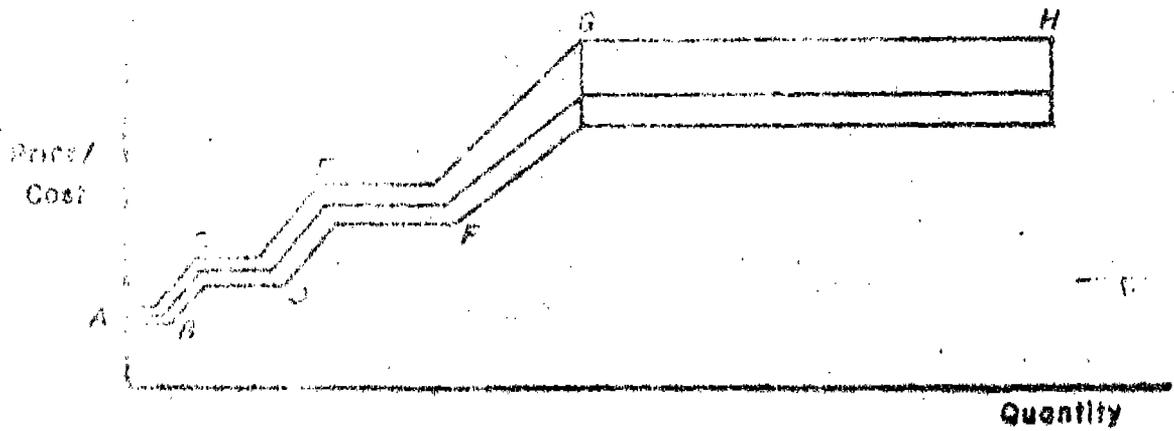
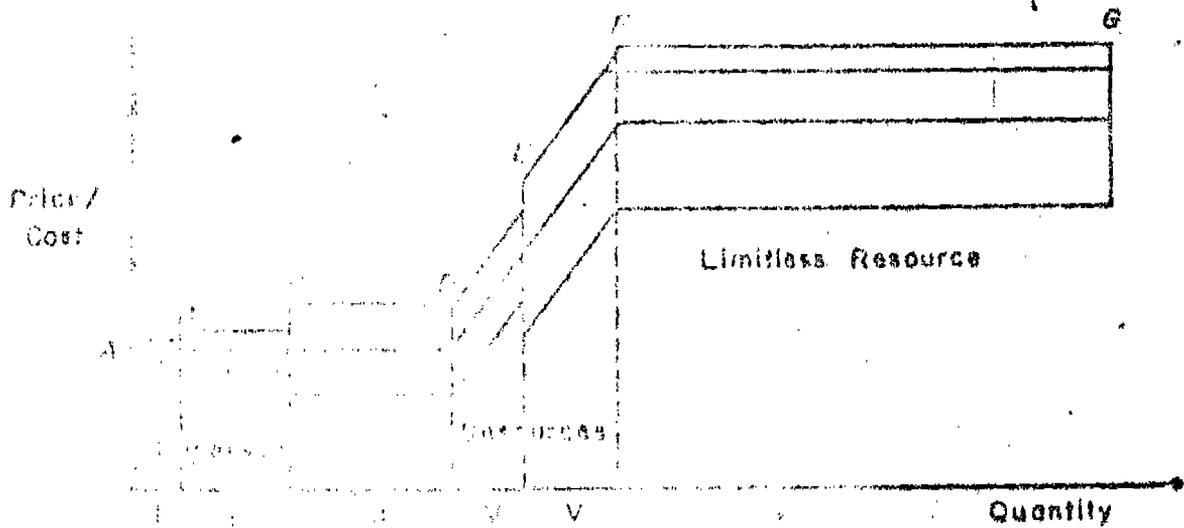


FIG 2<sup>nd</sup> LONG RUN MINERAL SUPPLY.



... OF THE ... SUPPLY CURVE

reserves and mine capacity can be increased. These time frames may be respectively referred to as the short run, medium run and long run.

In deducing the long run supply curve of minerals the following principles are essential:

(1) All stock concepts are mere estimates and therefore subject to errors. Some stocks are more precisely determined than others.

(2) Stocks defined from the cost price point of view, viz., reserves, submarginal and latent resources are associated with uncertainties arising from estimates of prices and costs.

(3) Stocks defined based on geologic knowledge such as known and undiscovered reserves are associated mainly with uncertainties in the estimates of sizes and grades.

(4) At least for some minerals, at a certain level of costs, a virtually limitless amount of resources may be available which tend to define the upper limit of prices for the minerals.

(5) As lower quality (higher costs) resources become economic, supply expands very considerably.

The preceding principles imply that the long run supply of a mineral ideally appears like a zigzag "curve" as shown in Fig. 2. Here the supply "curve" is shown as indeed composed of a series of broken bands with varying widths indicating the cost-price uncertainties. In addition, similar bands are associated with the horizontal components of the band which indicate the geologic indeterminacies of resource estimates. The uppermost band represents the upper limit to which all prices converge. The step-like character of the bands, which increase in width towards higher level, indicate the general trend that more resources can become available at higher costs. Alternatively, it implies that the price elasticity of supply increases as price increases and even approaches infinity as the level of limitless resources is reached.

Further implications of the supply function have bearings on how supply may be expanded. Supply can be expanded either by movement along the cost/price dimension or along the geologic dimension. Since costs may be influenced by technological improvement, by improvement of human skills by development of infrastructures, by easy credit, or by government policies and since prices are moreover affected by product improvement, access to market and government policies, among others, then any or all these factors may be managed to expand supply. Similarly, expansion of supply can also be effected by

decreasing uncertainties about mineral deposits as can be done by increasing investments in basic geologic information and exploration. Suffice it to say for the moment that proper understanding of the deduced supply function can be used to explain a number of resource phenomena and broadly predict mineral resource behaviour. This supply function can therefore be used for policy making.

#### Economic Theory of Mineral Production

This section sets down briefly the facts and principles that govern the behavior of a mineral industry or firm. It identifies and discusses the motive force that impels mineral production to move one way or the other, deduces the conditions for equilibrium, and presents some possible solutions for determining how much and when to produce and at what price. Discussions in this section are mainly based on the excellent review by Morse, C. (1976), inspired by Gordon, R., (1975), and assured by Solow, R. (1974).

#### Sources of Rent

A mineral deposit is very much like any man-made capital such as a truck or a petrochemical plant. Both a man-made capital and a mineral deposit provide streams of benefits or useful services over

time which terminate at some future time. They differ, however, in the sense that the man-made capital is reproducible while a mineral deposit is exhaustible. A unit of mineral extracted from the ground is lost from the mine, forever, so that the mineral becomes scarcer as more are produced. Consequently, a rational operator will not produce mineral unless the price exceeds costs, or he realizes positive rent because he could always postpone production and reserve the mineral until such time when rents can be realized. The reservation of mineral for future production is essentially an act of investment in mineral resources motivated by the desire to earn rent. In order to understand mineral rent more deeply a discussion of the source of rent follows.

Assuming competitive market conditions in the short run a firm may find itself charging a price that exceeds the cost of production, i.e., a surplus. If such arises from natural resources it is called rent; but if it is realized from man-made capital it is called either quasi-rent or pure profit. Our main concern at present is rent. We can distinguish three kinds of rents, the Malthusian, Ricardian, and rent due to exhaustion.

Under the Malthusian scheme, land (or mineral resources) are homogeneous in quality and fixed in amount. In the early stage of production enough land are available for any use, and it will be used to the point where the marginal product is zero, given any mix of labor and capital. Under the situation land is essentially a free good and its opportunity cost or the return from one best alternative employment is zero, and no price can be charged for the use of the land. However, when all land were under cultivation a price can be charged for the use of a unit. In fact, users will be willing to pay a price for use of the land because of the resulting resource scarcity, this price may be called Malthusian rent. It is the cost of using a finite resource which has become scarce relative to the demand it is facing.

Ricardian system, however, presumes that resources (minerals) are relatively limitless but are of different economic quality. That is, the costs of production from different pieces of land are different, which may arise due to variation in fertility, location and other attributes. Given the technology and the level of labor and capital employment, there is always some piece of land which yield zero rent. For land better than marginal, the price of the product exceeds costs. This surplus resulting from the differences in resource quality is called Ricardian rent.

Finally, in the exploitation of exhaustible resources such as minerals, rent must be a logical condition for production. As a finite exhaustible resource is produced and used it is depleted and becomes scarcer; hence its price rises. A producer, therefore, must decide whether to produce now or in the future knowing that if a certain minimum surplus is not realizable now it will be in the future. Hence a rational producer must charge a "reservation price" for producing now instead of in the future. This reservation price is the opportunity cost of present production, the rent due to exhaustion, and the guiding principle for the allocation of exhaustible resources. It follows that even the least "profitable" mine must earn some rent.

#### The Pure Theory of Exhaustion

Although the pure theory applies to production of exhaustible, limited and irreplaceable resources, emphasis here is put on mining. This section aims to identify the major factors and principles that govern mineral production. Specifically it seeks to find the conditions for equilibrium of the firm.

The theory assumes that under competition every mine earns at least a "normal" rent. In particular, subsequent discussions refer to mines (marginal mines) which earn but the normal rent. The theory

further presumes that a mineral producer will try to maximize the present value of the rent earned over the entire life of the mine.

For a marginal mine, let  $R^*$  be the rent earned over the period  $t$ , which is the difference between the total revenue ( $R$ ) and total cost ( $C$ ). Then

$$(4) \quad R^*(qt) = R(qt) - C(qt)$$

The notation  $qt$  designates the output during time  $t$ . A similar definitional equation can be written for marginal rent  $MR^*$ , where  $MR$  is marginal revenue and  $MC$  is marginal cost:

$$(5) \quad MR^*(qt) = MR(qt) - MC(qt)$$

Given the rent for any time period, the mine operator must maximize the present value of the rents accruing to the mine subject to some constraints. The objective function of the mining firm may therefore be stated as follows:

$$(6) \quad \text{Max} \sum_{t=0}^T [R(qt) - C(qt)] e^{-rt} =$$

$$\text{Max} \sum_{t=0}^T R^*(qt) e^{-rt}$$

$$\text{Subject to} \quad \sum_{t=0}^T qt - Q \leq 0$$

where  $T$  is the terminal period of the mine when reserves run out,  $Q$  equals the total mine reserves, and  $r$  is the discount rate. Alternatively, eq. 3 may be written in terms of the La Grange multiplier, hence:

$$(7) \quad L(q_0, \dots, q_T, \lambda) = \sum_{t=0}^T R^*(qt) e^{-rt} - \lambda \left( \sum_{t=0}^T qt - Q \right)$$

Subject to:

$$\left( \sum_{t=0}^T qt - Q \right) < 0$$

In order to maximize the preceding function we differentiate eq. 4 and equate to zero:

$$(8) \quad \frac{dL}{d(qt)}(q_0, \dots, qt, \lambda) = MR^*(qt) e^{-rt} - \lambda = 0$$

for any time  $t$ . For the case of  $t = T$  we have

$$(9) \quad \frac{dL}{d(qt)}(q_0, \dots, qt, \lambda) = MR^*(q_T) e^{-rT} - \lambda = 0$$

By subtracting eq. 6 from eq. 5, we get the necessary and sufficient condition for the equilibrium of a mining firm, that is,

$$(10) \quad MR^*(qt) = MR^*(q_T) e^{-r(T-t)}$$

$$\text{Subject to } \sum_{t=0}^T qt - Q < 0$$

This equation states the optimal condition for producing a finite exhaustible resource though in a form that is not easy to understand. It says that the marginal rent for any time  $t$ , is measured by the marginal rent at the period of exhaustion,  $T$ , discounted to time  $t$ . Alternatively eq. 10 states that the marginal rent for any year  $t$  equals the present value of the marginal rent for year  $T$ , where present refers to time  $t$ .

Alternative and more comprehensible statements of the equilibrium of the firm states that if  $t = 0$ , that is, when the point of reference is the time when the mine is just starting. Hence, eq. 10 takes the form

$$(11) \quad MR^*(q_0) = MR^*(q_T) e^{-rT}$$

Eq. 11 states that the present value of the marginal rent at the terminal period of the mine must equal the marginal rent when the mine just started ( $t = 0$ ). Dividing both sides of eq. 11 by  $e^{-rT}$  we get

$$(12) \quad MR^*(q_T) = MR^*(q_0) e^{rT}$$

which indicates that at equilibrium the marginal rent must grow exponentially according to the "normal" rate of interest such that at the terminal period the marginal rent equals the compound

marginal rent at the beginning of the period. If say  $MR^*(q_T)$  were greater than  $MR^*(q_0)e^{rT}$ , then the operator could realize more rent by producing at a later period rather than earlier; however, if  $MR^*(q_T)$  were less than  $MR^*(q_0)e^{rT}$  then the operator would have been induced to produce more during the earlier period because he stands to realize more rent thereby. Therefore, eq. 12 indeed states the condition under which the mine operator would not like to alter his production pattern because there is no other schedule that would allow him to realize more rent.

More revealing relations impinging on pricing an exhaustible product comes to the surface if we express marginal rent in terms of its components, i.e.  $MR^* = MR - MC$ . The general equilibrium condition in eq. 10 now takes the form:

$$(13) \quad MR^*(qt) = MR(qt) - MC(qt) = MR^*(q_T)e^{r(t-T)}$$

which by rewriting becomes

$$(14) \quad MR(qt) = MC(qt) + MR^*(q_T)e^{r(t-T)}$$

This shows that at equilibrium the mining firm will not set marginal revenue to marginal cost, as any competitive firm would, but for any level of output,  $qt$ , the equilibrium operator will set marginal revenue equal to cost plus the present value of the marginal rent

forgone in the future due to the output today. The marginal rent forgone in the future is the marginal opportunity cost, which is otherwise called reservation cost or marginal user cost. We may therefore define marginal user cost,  $MuC$ , as follows:

$$(15) \quad MuC(qt) = MR^*(q_T)e^{r(t-T)} = MC^*(qt)$$

where  $MC^*(qt)$  is the marginal aggregate cost of the mine operator.

If price equals marginal revenue, as it should be under competition, then eq. 14 says that the price of a mineral product exceeds cost by the amount of the marginal user cost. To generalize, at equilibrium, producing exhaustible products must charge a price larger than those dealing in non-exhaustible resources. Price charged by the extractive firm must be greater by the amount of the opportunity cost forgone in the future.

A final form of the equilibrium condition for the mining firm may be developed to address some problems on the social plane, such as conservation or pollution. By analogy of the equilibrium condition for ordinary firm,  $MR = MC$ , where we interpret revenue as benefits and cost as cost or damage, we can state the criterion of equilibrium for a mining and related firm as

$$(16) \quad MuB(qt) - MuC(qt)$$

which says that equilibrium requires the equality of marginal user benefit (MuB) and marginal user cost for any time  $t$  and output  $q$ . Equation 16 indicates further that production shifts toward the present if marginal benefit exceeds marginal cost and into the future if marginal cost is the greater.

Additional information may be extracted if marginal user cost and marginal user benefit are defined in more detail. Hence

$$(17) \quad \text{MuB}(q_0) = \text{MR}^*(q_0) = \text{MR}(q_0) - \text{MC}(q_0),$$

$$(18) \quad \text{MuC}(q_0) = \text{MR}^*(q_T)e^{-rT} - [\text{MR}(q_T) - \text{MC}(q_T)]e^{-rT}$$

We note that the marginal user cost must measure the present negative value to society of future decrement of output, the measure of the marginal social cost of exhaustion. If firms deliberately consider the marginal user cost in their pricing behaviour, then exhaustion is indeed a social problem, otherwise exhaustion is not considered a problem worth bothering about.

It is now appropriate to inquire, under what conditions would exhaustion be ignored by the mining firms or industry? Examination of eq. 18 provides a few answers: (1) If  $T$  is very large, then  $\text{MuC}$  approaches zero. This means that if the stock of resources is very large relative to output then the producer will not worry about

exhaustion. Similar effect results if large volume of a substitute or alternatives exist. (2)  $MuC$  also approaches zero if the opportunity cost of capital is very high. This means that when capital is very scarce, or when investments become extremely risky, or when inflation gallops at extremely high rates, then the effect of exhaustion may be ignored. (3) Finally, if marginal rent approaches zero, either because marginal costs are too high or marginal revenues are too low, exhaustion will also be ignored. This implies that all factors tending to make mineral prices low, or making costs quite high will ignore exhaustion. (4) Other factors which tend to undermine the operation of a competitive market such as lack of information, immobility of economic factors, unreasonably high taxes, and monopsony, among others, would also undermine efforts at conserving.

#### Models of Intertemporal Allocation

The question of how much to produce, at any time, and at what price, can be answered if a mechanism exists so that marginal rent grows at a rate equal to the opportunity rate of interest. Since  $MR^* = MR - MC$ , marginal rent can only increase if either (1)  $MR$  rises as  $MC$  remains constant or if (2)  $MR$  remains constant as  $MC$  decreases. The first leads to the rising price case or Hotelling-

Herfindahl-Gordon model, while the second gives rise to the decreasing cost case or the Gray-Scott model. Though these models require highly restrictive conditions they provide valuable insight into the allocational problem of the mining firm.

Industry Equilibrium Under Hotelling's Rule:  
Rising Price Case

Under competitive equilibrium the rent due the ore in the ground must grow at the market rate of interest  $r$ . If the rent grows faster than  $r$ , there will be no production since the mine operator can increase rent by producing in the future; while if rent grows more slowly than  $r$ , then the operator will shift production towards the present, since he will earn more by reinvesting his income at the prevailing market rate. In symbol, Hotelling's Rule may be stated as follows:

$$(19) \quad R_t = (P_0 - \overline{AC}) e^{rt}$$

where  $R_t$  is rent in year  $t$ ,  $P_0$  is price at the beginning of the period,  $\overline{AC}$  is constant average cost which is equal to the marginal cost, and  $r$  is the market rate of interest.

Since  $R_t = (P_t - \overline{AC})$ , then eq. 19 becomes

$$(20) \quad P_t = (P_0 - \overline{AC}) e^{rt} + \overline{AC}$$

This indicates that if rent grows at the market rate of interest, then the price of the mineral commodity must grow less rapidly.

Figure 3 illustrates the conditions surrounding Hotelling's rule. Panel (a) indicates the cost curves of a representative firm which produces  $q_t$  amount of cost  $P_t^1 = MC = AC = \text{constant}$ . Price increases from  $P_0$  up to  $P_t$  at which time the ore is exhausted, as demand is reduced to zero. In Panel (b) the path traced by increasing price is drawn starting from  $t=0$ , to  $t=T$ . For any time  $t$ , the difference between the price curve and the constant cost line represents rent as illustrated by  $R^*$ . In Panel (c) the demand for minerals, presumably covered by the industry output, are indicated by the intersection of a horizontal price line and the industry demand curve. Note that at the beginning of the period the demand of the industry was,  $q_t = Q_0$ , then decreases progressively until it equals zero at  $t=T$ . The diagram shows that increase in "price" (or rent) is achieved through rising prices, while increasing prices presumably occurs due to increasing scarcity of the resource.

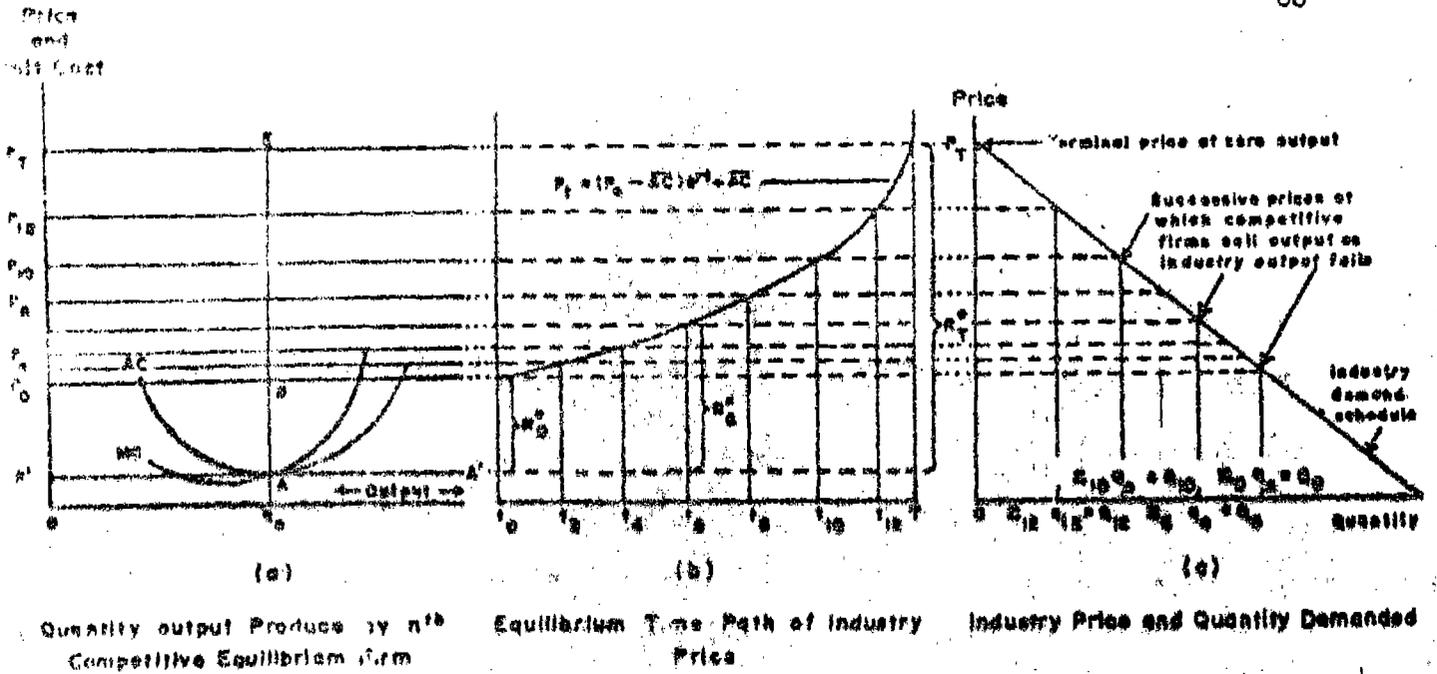


Fig. 3<sup>a</sup> Rising price case, with industry price increasing, according to Hotelling's rule.  
 (After C. Morse, 1916).

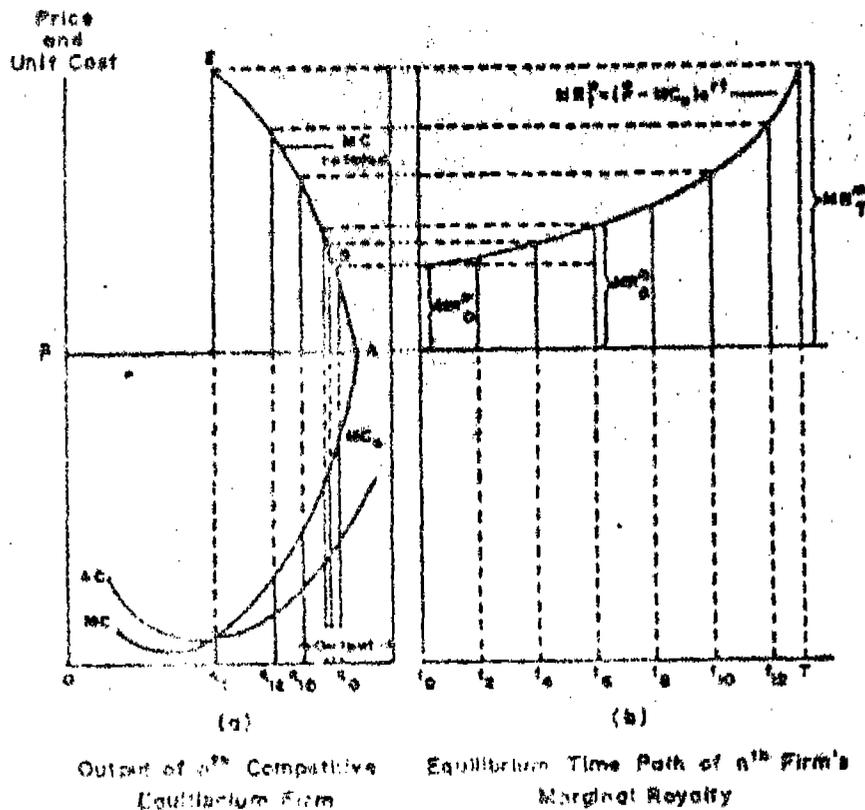


Fig. 3<sup>b</sup> Situation of a typical firm and its relation to industry equilibrium.  
 Decreasing cost case  
 (After Morse, 1916).

Firm and Industry Equilibrium Under  
the Gray-Scott Rule: Declining Cost Case

This model asserts that market price will remain fixed indefinitely and achieves the required growth rate of marginal rent by reducing output and cost. The equilibrium condition under the present situation is.

$$(21) \quad MR_0^* = MR_t^* e^{-rt}$$

or in terms of the component of marginal rent

$$(22) \quad (\bar{P} - MC_0) = (\bar{P} - MC_t) e^{-rt}$$

where  $\bar{P}$  is the constant price. Under conditions shown in Figure 3b, increasing marginal rent is realized by decreasing cost and production.

Figure 3b shows the equilibrium situation of a typical firm, the cost curves and decreasing output over time, and the path traced by increasing marginal rent from  $t = 0$  to  $t = T$ . The differences between the constant line  $P = \bar{P}$  and the marginal cost curve which decreases from  $q_0$  to  $q_t$  measures the marginal rent,  $MR_t^*$ , for various levels of output.

Common assumptions for the two models above are:

- 1) All firms have identical production functions
- 2) All the markets in which they operate are competitive and all the firms are marginal.
- 3) Each firm produces, either at minimum average cost so that  $MC = AC$ , or does not produce at all.
- 4) Costs do not change as a function of cumulative output.
- 5) Demand, technology and other relevant parametric conditions are constant.
- 6) Each firm has perfect knowledge about all facts bearing on its decision concerning output, demand function and stock of ore in the ground.

Although the preceding models were developed under highly specialized conditions they serve as important devices for analyzing the effects of changes in the industry. For instance, the effects of cumulative output, research, substitution, exploration and development upon stocks were analyzed by Morse, C., (1976, p. 242-244) using the two models.

At this point we have already sketched the basic framework of the theory of mineral supply. The following section focuses on a number of selected issues affecting the mineral industry with strong policy implications.

## SELECTED TOPICS ON RESOURCES

Topics which are deemed useful for formulating mineral policies are treated under this heading. Among them are a model for transforming exhaustible resources into renewable and increasing assets, the role of minerals in development, factors of mineral development, the conflict over sharing of mineral rent and some policy guidelines.

## A Resource Transformation Model

A unit of exhaustible resource, say a ton of ore, can either be consumed, invested in capital goods, or reserved for the future. Whichever alternative is taken will affect the welfare of the present and future generations in some way. Morse, C. (1976) developed a model, which is presented in abstract form below, that investigates the consequences if a ton of ore is consumed, invested in productive capital or reserved for the future, an exercise which leads into important insights as to what the present generation may do to enhance the welfare of future generation.

Implicit in the model is the assumption that the use of a preference rate in evaluating investments is biased in favor of the present generation and that discounting future values to the present is a way by which the present generation protects itself against

the claims of the future generation. On the other hand, saving by investing in productive capital goods is a mechanism by which the present provides for the welfare of the future generation. In fact, even the present generation derives benefits while its investments grow. The model is presented below.

Suppose that by mining a ton of mineral today we can increase the output of either consumption goods,  $C_0$ , or capital goods,  $I_0$  such that the value of the additional social product,  $Y_0$ , obtainable by producing the mineral rather than reserving it is  $MR_0^*$ , the marginal rent at present. Hence  $Y_0 = C_0 = I_0 = MR_0^*$ , although  $C_0$ ,  $I_0$  and  $MR_0^*$  are mutually exclusive. This means that the mineral can be transformed into a consumable or productive man-made asset. It may be assumed, moreover, that if we invest in a productive asset there will be continuous re-investments so that  $I_0$  grows at the rate  $s$ . If  $Y_t$  is the level of social output for time  $t$ , then we have:

$$(23) \quad Y_t = I_0 e^{st}$$

The present value of  $Y_t$  is therefore

$$(24) \quad Y_0^1 = Y_t e^{-rt},$$

where  $r$  is the going rate of time discount.

If  $s = r$ , it follows that  $Y_0^1 = I_0 = Y_0$ ; then whether the mineral is transformed into consumption goods,  $C_0$ , or into productive assets,  $I_0$ , is a matter of indifference to the investor and his generation. However, the mineral consumed now does not benefit the future generation, whereas the latter will benefit from the increased flow of goods and services resulting from the invested ore. Therefore, the future generation will prefer that the present generation invests rather than consume the mineral which the latter produced.

If, however, the mine owner elects to reserve the mineral rather than consumes or invests it, and suppose that the marginal rent,  $MRO^*$ , grows at the rate  $\sigma$ , then the marginal rent for any period,  $MRT^*$  is:

$$(25) \quad MRT^* = MRO^* e^{\sigma t}$$

and its present value,  $MRO^{**}$  is

$$(26) \quad MRO^{**} = MRT^* e^{-rt}$$

If  $\sigma = r$ , then  $MRO^* = MRO^{**}$ ; hence the mine owner would be indifferent whether he engages in reserving the mineral or investing it in man made assets. As for the future generation, it will prefer that investment in productive assets be made since it will benefit from the future flow of goods and services while merely keeping the

mineral in the ground will confer nothing, except that the mineral may still be available for use. In particular, as far as the owner is concerned, reservation and investment in productive assets can be a matter of indifference since the private benefit accruing to him from either is the same, but as far as the future society is concerned, it will gain nothing because the rent that the owner derives is balanced by the cost of extraction (assuming marginal mine for simplicity), actually a loss to society (if the mine owner is momentarily excluded). In fact, as a consequence of reservation, future society is poorer by the amount of goods and services that would have been made available, including the capital that would have grown, had the ore been extracted and invested in productive assets.

In real life, it is most likely that part of the produce will be invested and part will be consumed. Of course there are situations in which either the mineral produced is completely consumed, reserved, or invested.

Several important principles can be deduced from the model:

(1) An exhaustible asset can be transformed into renewable and growing man-made assets, an act which is biased in favor of future generations, though the present generation derives benefits too, in form of employment and increased goods and services, as the asset grows into the future (2) Reserving exhaustible resource into the future benefits

only the (future) owner but not the society as a whole, since the social gain from the rent is exactly negated by the social cost of producing the mineral. In fact, the future generation would have been worse off by the amount of goods and services that did not materialize consequent to reserving the mineral instead of investing in man-made social capital, such as schools, hospitals, roads, factories, professionals, and the like. (3) By consuming all products of exhaustible resources only the present generation benefits while the resources are lost to the future generation forever. (4) Conventional discounting can be biased in favor of the present, or future generation, or be made neutral, by manipulating the discount rate so that it is respectively greater, less than, or equal to the real growth of capital stock or of production.

These conclusions imply that the present generation can ethically and rationally draw from the stock of exhaustible resources to optimize economic growth, as Solow, R. (1973) concluded<sup>1</sup> provided they add to the stock of reproducible capital. In fact, the statement can be made even stronger, that is, the present generation must harness its stock of exhaustible resources and invest at least a reasonable proportion in renewable man-made capital to improve the lot of the future generation. Mere reservation, though preferable to present consumption, is suboptimal to the welfare of future generation.

## Role of Minerals in Development

Natural resources play important role in the development of societies. The juxtaposition of coal and iron, for instance, in countries like England, the U.S.A. and Germany have been cited as the basis for their becoming great industrial countries. Although some authors insist that possession of minerals are not indispensable to development, as the experience of resources poor countries such as Japan and the Netherlands indicate, still minerals are needed and must be procured by means such as trade. The broad theoretical basis on the role of minerals in growth is authoritatively developed by Barnett, H. and C. Morse (1963) while the more specific contributions of minerals to developing and developed countries are articulated by Mc Divitt, J. and Jeffreys (1976) and Toombs, and Andrews (1976). The ideas presented below are derived from these works.

The strong awareness about the importance of resources led the classical economists - Malthus, Ricardo and Mill - to the formulation of what is now known as the doctrine of increasing resource scarcity. "It predicts that scarcity of natural resources would lead to eventually diminishing social returns to economic effort with retardation and eventual cessation of economic growth." Implicit in the doctrine is the changing role of resources in the various stages of economic growth; abundance in the early stage feeds growth by compensating for

deficiency in man-made capital and labor with abundant resources, while more abundant capital and skilled labor during the later stages propel growth, although constrained by increasing resource scarcity. The notion of changing role of resources over time should tie this section to the transformation of depletable resources into man-made resources.

The doctrine of increasing resource scarcity makes stringent assumptions. Among others, it presumes complete knowledge of resources, that the social production function is one of constant returns to scale with single homogeneous product, and there are no social and technological progress. Three variants of the hypothesis with somewhat differing premises - Utopian, Malthusian, and Ricardian - are recognized. To relate the hypothesis to the real world the simplifying assumptions are relaxed. In symbol, the hypothesis takes the form:

$$O = f (R, L, C)$$

where  $O$  = the homogeneous social product;  $R$  = resource,  $L$  = labor; and  $C$  = man-made capital; all expressed in physical units.

Under the Utopian case, natural resources are presumed homogeneous and unlimited relative to demand. Growth then is unconstrained

by the scarcity of resources but rather by limited man-made capital and labor. Assuming that technology remains constant which requires constant C/L ratio, growth proceeds only if capital increases relatively faster than labor. Without capital growth while population increases, it is possible to experience negative economic growth, even in Utopia, where resources are unlimited. But as shown earlier, exhaustible resources can be transformed into man-made capital, so that the latter can grow at least in the same pace as labor. Hence, although in the Utopian case resources do not seem important to economic growth because they are unlimited and do not constrain growth, their value arises from the premise that they can be transformed into currently scarce man-made resources which can accelerate growth. In short, while natural resources are quite plentiful they are not important impediment to growth but are valuable as a factor facilitating economic growth. The early stage of a society's development, when resources are relatively more abundant than the demand of population, is akin to this Utopian case.

By assuming that resources are finite and exhaustible, the Utopian case transforms into the Malthusian Model. Basically, it describes a Utopian growth path, constrained only by the availability of labor and capital, until the upper limit of resources is met.

Growth rate diminishes as this limit is reached as a result of diminishing returns to labor-capital input until growth grinds to a halt. Depletion of finite resources hastens the approach of growth to its destined limit.

More appropriate to mineral resources analysis is the Ricardian Model. It differs from the Malthusian in assuming that resources are unlimited in amount, heterogeneous in economic quality and that they are used in the order of decreasing economic quality. This model implies that decreasing quality of resources constrains growth to a lesser extent while high quality resources are available, but increasingly as it becomes necessary to utilize lower grade resources. The limit to growth is reached when additional labor-capital input yields no extra output. As in the Malthusian Model, depletion hastens the approach of the limits to growth.

Clearly the preceding models show the important, though grim, implication of increasingly scarce natural resources to economic growth under a set of restrictive assumptions, such as fixed sociotechnical conditions, homogeneous product, complete knowledge and sequential use of resources. When these conditions are relaxed, one after the other, to bring into correspondence with reality, the grim implications are alleviated if not completely banished.

For instance, by relaxing product homogeneity, one recognizes the possibility of shifting from a product which has become expensive due to increasing resource scarcity to a substitute which is relatively cheaper, thus relieving part of the burden on the scarce resource and arresting the approach to the limit to growth. The more numerous and diverse the products are, the more effective this substitution antidote is to parrying resource scarcity. By relaxing complete knowledge and fixed sociotechnical conditions, the adverse impact of fixed and exhaustible resources on growth is minimized, or even become meaningless, since new resources will be discovered by exploration or created by technological innovations and by providing new social, political and economic arrangements.

Empirical test of the increasing resource scarcity hypothesis for the U.S.A. during 1870-1957 was very revealing. Instead of increasing costs as predicted, it was shown that the costs of producing natural resource products, such as mineral and agricultural, substantially decreased except for forest products which increased. This phenomenon was ascribed to the non-operation of the restrictive assumptions, particularly to the variety of substitutions as well as to discoveries and the numerous technological innovations during the period.

The Malthusian spectre recently surfaced (D.H. Meadows, et.al., 1972) again warning the world about a catastrophic approach to the limits to growth due to, among others, exhausting of limited resources. The preceding discussions can be used to analyze the implication of this modern form of the Malthusian doctrine. But the ultimate relevance of this piece of work is its message that natural resources are important to society and must be considered seriously in designing any policy or program for society.

Focusing on mineral resources, McDivitt, J. and Jeffrey (1976) articulated the thesis that the development of mineral resources, especially for societies in the early stage of development, have been (though not in all cases) and can be instrumental in promoting growth and development. Among the specific contributions are foreign exchange which can be used to secure man-made capital, government revenues for building infrastructure and maintaining peace, profits and royalties which can be re-invested: employment and wages; and positive effect on other economic sectors which provide the mining operation goods and services. Being situated in areas which are undeveloped and barely populated, the development of a mine requires the construction of roads, bridges, power facilities, schools, hospitals and other social amenities. But most important, the exposure of people to highly complex operations which are non-traditional,

scientific, help create an environment that is receptive to development. Mining, therefore, contributes to growth by way of capital formation; by stimulating activities in other industries; by providing employment; by increasing national product and government revenues. It contributes to social and economic development by helping create an atmosphere receptive to development, by providing mobility, educational and health care facilities, where none existed before. It is also true, however, that the operation of mining facilities did not result to effective development in some places for reasons that have to be properly understood.

Viewed from another angle, Toombs, R.B. and P.W. Andrews (1976) indicated that minerals are also important to developed economies because they are essential input even to their manufacturing and service industries. Though mining contributes but a small fraction of national product, it is argued that mineral based products contribute very substantially to national production. Needless to say without the mineral based fuels, industries will grind to a halt. It is implicit in the paper that possession of mineral resources is not essential for economic growth and development, provided they are obtained by trade, but without minerals these great industrial countries could not have attained their present status.

If minerals are indeed important to the growth of a society, how then can we promote their development to increase their contribution to national welfare? What are the factors that affect its development?

### Factors of Mineral Development

Factors affecting mineral development which may be used as broad framework for designing a mineral development policy are identified in this section. It is followed by a discussion of the source of conflict that attend the sharing of rent. Finally we focus on some policy topics which have important bearing on mineral resources development.

### Conceptual Framework

Mineral development can be thought of as a production process in which development, depends upon a number of variables. It may be conceptualized as follows (after Santos, T.M. and D.C. Saliva, 1980; Santos, T.M. and F. Golaz, 1979).

$$(28) \quad Q = f(F, G, E, I, T)$$

that is, the development of the mineral industry,  $Q$ , depends upon factor endowment,  $F$ ; domestic social, political and economic

conditions, G: global economic environment, E: investments, I: and state of technology, T.

A factor refers to a material or agent which provide valuable services in production. It may be physical, human and institutional. The physical factors may be favorable geology, various types of resources or reserves. On the other hand, human resources represent a body of people with skills, experience, or knowledge which would allow the efficient performance of a given task. Institutions refer to agencies that give instructions, plan, manage and develop the industry. In general, the greater the factor endowment the better are the chances for development.

The state of technology refers to the processes, techniques, procedures and stock of knowledge that may be availed of for mineral production and related activities. It may also refer to the stage of development of the country and may be constrained by the availability of work force sufficiently numerous and possessing diverse skills to fill the needs of the various stages of mineral and related operation, as well as by institutions that promote and facilitate such activities such as schools, laboratories, research institutes and regulatory bodies. In a sense the state of technology can be conceived of as an element of a country's factor endowment.

Whether a country's mineral industry will prosper or not, given adequate technology, institutions, mineral resources and pool of skilled man power, will depend not only on the peace and order situation but also on the attitudes and perceptions about the need for the industry. The perceived value of the mineral industry to the national welfare, superimposed on the prevailing political, economic and social arrangement determines the nature of policies and laws that govern the industry.

Since minerals are global commodities, the domestic mineral industry is affected by international developments. Factors affecting world demand, supply and prices as well as access to market influence the domestic industry. Booms, recessions, wars, and rebellions, among others affect the supply-demand balance and prices. So would a major technological breakthrough such as the mining of ocean nodules.

Finally, investments are essential to the development of the mineral industry. Investments in exploration, development and production facilities are familiar. But less familiar ones come in the form of geologic maps, surveys, monographs, mining schools, research institutes and the like. The size and quality of the country's factor endowment is therefore determined by the level of investment.

These factors, which are indeed very complex either promote or inhibit the development of the mineral industry. Any major problem, in any of these variables, could thwart mineral development, but they must co-exist to have a viable mineral industry.

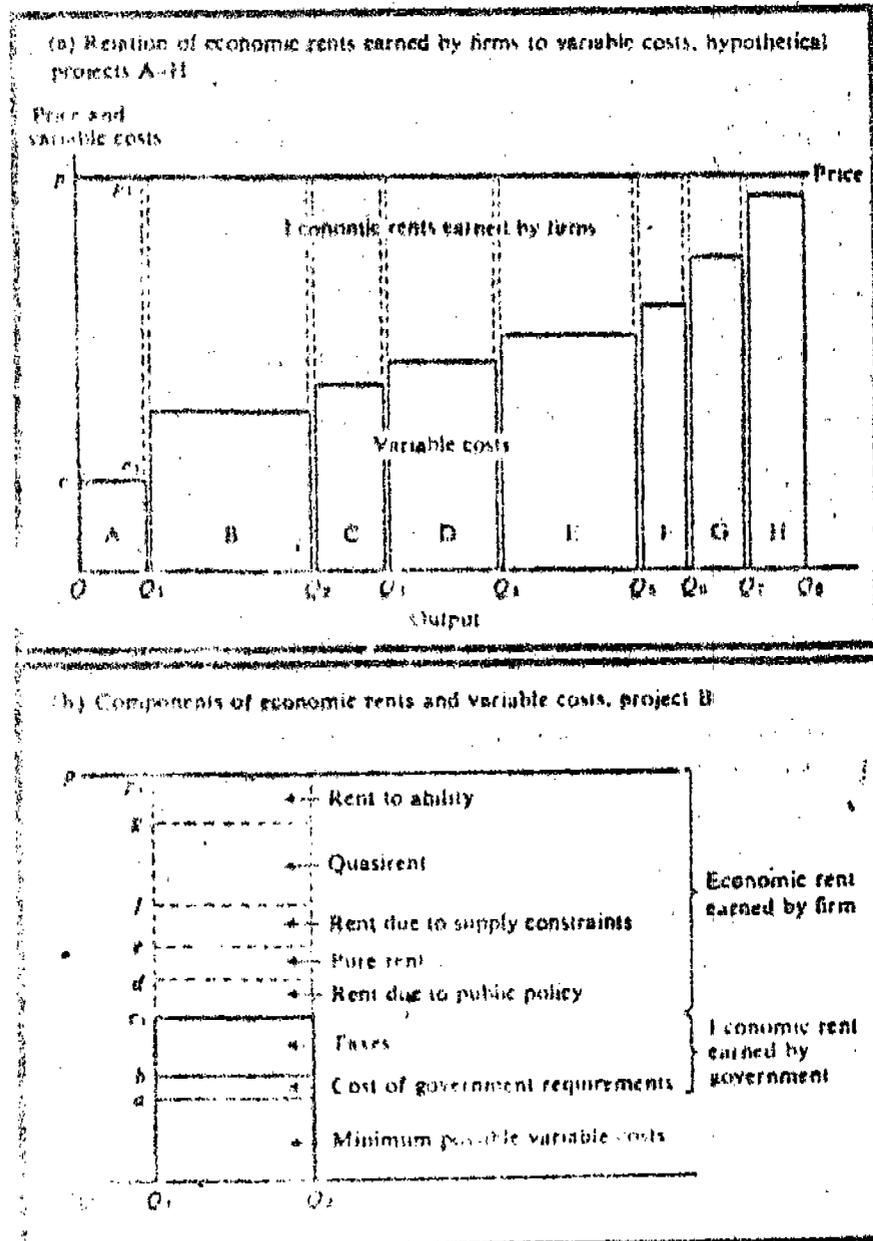
The domestic economic, social and political conditions find expression in government policies and actions. Conflict between the mining operator and host government, in the partitioning of rent may be disruptive, hence, an analysis of the sources of conflict in dividing rent is given below.

#### Conflict Over Rent

Granted that private investments are essential for mineral development, it is necessary to avoid conflicts between investors and host government. Knowledge about the sources of conflict may therefore be helpful for avoiding such conflicts. Since the division of profits or rents is a common source of controversy or misunderstanding the kinds of rents, their composition and policy implications are discussed below based on the works of Mikesell, R. (1971) and Tilton, J.E. (1977).

As indicated earlier, rent from mineral operation is that portion of price that remains after subtracting the variable costs or out of pocket expenditure of the firm. The

Figure 4 Sources and Composition of Economic Rents for a Mineral Industry (After Tilton, J.E., 1977).



magnitude of rents vary among projects because of their differences in such characteristics as grade, tonnage, amount of overburden, mineralogy and location, among others, as shown in the lower panel of Figure 4 where A, B, ..., H are different projects. It is instructive to decompose into its components the rent associated with the operation, as done in the lower panel of Figure 4. The price of a mineral commodity may be divided into three categories: (1) minimum possible variable cost; (2) Economic rent earned by the government; and (3) Economic rent earned by the firm.

As stated earlier, a firm must recover its variable costs, or its out of pocket expenditures in order to stay in operation. Or else, it would be rational to quit.

Rent earned by the government consists of taxes and government requirements. Income tax, royalties, bonus, sales tax, export tax are examples of rents which accrue to the national treasury. But impositions such as the requirement to control air and water pollution, to locate industrial zones outside a restricted zone, or the conversion of oil-burning plant to coal burning, are also rents earned by the government, measured by their costs, though not normally understood as such.

Five elements comprise the rent earned by a mineral firm: rent due to public policy, rent due to supply constraints, pure rent, quasi-rent and rent to ability. For policy makers who are trying to maximize public revenue, it is necessary to understand the implications of appropriating any or all of these rents.

Rents which may be taken away from an operating firm without serious supply implications are: (1) Rent due to public policy which may arise because countries treat their mineral industries differently, e.g. one may charge 50 percent income tax, while another may require just 35 percent; or one may permit depletion allowance, while others completely disallow it. In short, this rent usually results from public policy designed to attract investments but which differ from one country to another because of varying perceptions about the social value of the enterprise. (2) Rent due to supply constraint which may arise because a firm may be large enough to affect, at least in part, production and price levels. (3) Pure rent, which results from a mine's superior attributes, such as high grade, large tonnage, shallow burial and low cost location. Although these rents may be taken away from an operating firm without adversely affecting production, such an act will diminish the attractiveness of new investments.

Quasi-rent and rent to ability can only be appropriated at certain costs. Quasi-rent corresponds to returns to fixed factors such as capital. Since once committed, capital can not be easily transferred, a firm will still continue to operate without quasi-rent provided it recovers variable costs. This situation, however, would discourage additional capital outlay leading to deterioration of existing facilities and drive away new investments. Finally, rent to ability derives from a firm's specialized skill, knowledge, experience, market, connection, or technology which enable it to produce at costs lower than others. This rent must be captured by the firm or else it will simply cease from operation because ability resides in factors that are mobile.

Tilton, J.E. (1977) and Mikesell, R.F. (1971) discussed cases in which conflicts between the host countries and the investors in the division of rent led to deterioration of the investment climate resulting in subsequent reduced investments. This was the case in Canada and Australia during 1970-1974, in Chile in the 1960's, as well as in Peru, Papua, Zambia and Zaire after World War II. Moran, T. (1974) even made a very incisive analysis of the struggle for the nationalization of Chilean copper mines.

The preceding discussion described the various components of price and their behavioral implications relative to the firm. They

can help the development planners find a way to induce firms to contribute to development in an optimal way. However, it may be difficult to measure these concepts although they are conceptually useful but measuring them is not impossible though (Hughs, H., 1978).

Apart from rent sharing, conflict may also arise when the government expects a firm to contribute to activities such as equalization in income distribution, provision for employment, manpower training, protection of the environment and the like, which may be inconsistent with the goals of a private enterprise. These problems, along with rent-sharing, are important policy issues.

#### Some Policy Guides or Issues

Broad policy guidelines, elements of a model mineral policy, and brief review of mineral policies in the U.S.A. are presented here.

The important role of natural resources in a country's development is generally recognized (UN, 1970). Such role may be internalized in a country's mineral policy subject to the following principles:

- (1) A country has the inalienable right to sovereignty over its own natural resources and must be able to exercise this right in the interest of its own development, in accordance with its laws and

treaty obligations. (2) Development of natural resources is an obligation of a government to its own people because it is the basic element of development in the country, and to the international community because of the economic, technological and social interdependence of countries of the world. (3) The country as a whole must benefit from resource development. (4) The natural resource operation must seek to promote general development to the extent possible as would for example, the construction of all weather roads where none existed before. (5) The long term and short term effects must be balanced.

The implementation of these resource policies may vary according to the following constraints: (1) Degree of development and absolute economic wealth of the country; (2) immediacy of need; (3) ecological characteristics of the country; (4) nature of the resource, considering things like its value to life or value per unit weight; (5) population density; and (6) level of education and institutional development, taking into account the quality of available trained personnel, as well as the administrative and analytical service (UN, 1970).

More specific guidelines, however, may be needed to effect mineral development. Such guidelines may be deduced from a model as spelled out below.

Elements of a Model Mineral Development Law<sup>1</sup>

There are three factors that must be considered in developing mineral development law: First, the objectives must be clearly specified but whatever they are they must "seek to bring about the maximum ultimate recovery of the resource, at the time when it is needed, and at costs which contemporary economy can afford." Second, the law must consider the interests of the state, viz., (1) that the state is a sovereign with plenary power over the property within its boundaries, whether owned by the state, its nationals or by foreigners; and (2) in most nations of the world the state is a proprietary interest of the surface owner. Third, the law must recognize the interest of the miner to attract venture capital. These interests vary according to stages. Elements that must be written into a mineral law, by stages, are:

In the reconnaissance stage, the desirable elements are:

- (1) The right to explore a maximum area, not necessarily on an exclusive basis, to enable the miner to decide as to the areas he will want to apply, later on, for an exclusive right; and
- (2) the right to freely import the equipment for such reconnaissance and to ship it home again after it has served its purpose.

<sup>1/</sup>Materials presented under this heading are abstracted from the work of Ely Northcutt (1969).

During the exploration stage two basic elements are essential to the investor: (1) the exclusive right to occupy a defined area and to explore for the minerals that interest him; (2) the assurance that, if he discovers minerals, he will have an exclusive right to develop and produce them, on terms known, to the maximum extent possible, in advance of his making his exploration investment and subject to a minimum likelihood of change in those terms.

Six assurance are required by investors in the production stage, they are: (1) Security of tenure for a period long enough to recover the investment, plus a profit commensurate with the risk and the magnitude of the investment made in the search for, and development of, mineral deposit; (2) The right to develop the resource he has discovered in accordance with his best business and technical judgement; (3) The right to sell or dispose of the minerals produced and to retain the proceeds; (4) The right to repatriate capital, profits and equipment; (5) Assurance of reasonable limitations on the State's financial exactions; and, (6) The right to resort to an impartial tribunal to decide disputes between the miner and the State.

A third interest that must be considered in developing mineral laws is the interest of the consumer. A mineral development law that necessitates high costs and high taxes may price that nation's

mineral production out of the international market. Or a mineral law that puts pressure on the miner to produce and export may leave the domestic users with very little of the resource at prohibitive prices.

Here now are the elements of a model mineral development law that attempts to reconcile the interests of consumers, producers, and the State: (1) Administration; (2) The document of title for reconnaissance, exploration and production; (3) Financial provisions; and, (4) Settlement of disputes.

Administration. Some agency of the government must be authorized to issue documents of title covering reconnaissance, exploration, and production. Three characteristics must be possessed by the administrative machinery: (1) Mineral law must be administered by honest and competent men who must be properly paid; (2) Transactions must be consummated with dispatch which can be made possible if power is concentrated in a single agency that keeps records, grant import licenses for equipment, issue mineral titles, collect royalties and taxes, grant permits for repatriation of capital and profits, among others; and, (3) A workable central system of maps and records must exist to help applicants for mineral determine what lands are open and for what minerals.

Before documents of title are issued, it is necessary to indicate who have the rights to the title; whether foreign corporations or nationals are allowed to possess them and under what conditions.

Documents of Title. For reconnaissance permits, identification of the holder, assurance of the right to import equipment free of duty and to repatriate it, and perhaps the requirement that the prospector shall turn to the government the result of his investigations, such as ecological maps, if he does not apply for exploration license. The permit may confer no right to sink wells or dig mines but may give a right to make seismic surveys and the like and use radio equipment.

As for exploration licenses, three sets of elements need be specified. First, as stated earlier, a mining company who would take the risk of mineral exploration must be guaranteed the ff.

(1) exclusive right to occupy a given area for a reasonable period so that he could protect whatever discoveries he made; (2) exclusive right, if minerals are found, to a lease or concession to exploit them, for a long period of time, on terms fairly defined at the time that the investment is first risked. The State, on the other hand, is entitled to demand that the holder shall indeed investigate them, not simply sit on them for speculative purposes. Four kinds of

incentives avoid this problem: (1) Restrict the exploration license to a relatively short period and few renewals; (2) Stipulation of a minimum stated amount of work or expenditures; (3) Fixed percentages of the original area may be relinquished on each renewal; and, (4) Imposing of a surface tax, its rate per unit area increasing with the number of such areas and over time, on occasion of each renewal. These incentives can help the state ensure rational exploration.

Production concessions. This title confers the holder the exclusive right to mine, produce and sell minerals over a long period of time. The following must be stated: (1) A production concession shall be issued, as a matter of right to the holder of an exploration license who makes a commercial discovery. (2) That if the area granted is large, then pressures should be put on the concessionaire to either develop or relinquish it; (3) The term of the permit must be long enough commensurate with the hazards of assembling capital and developing production, for a minimum of 20 years. Normally, the title must be renewed upon expiring provided the holder shows evidence of reasonably developing the property. Safeguards, however, may be necessary which may take the form of progressively increasing rentals on blocks of the concession area not developed, or requirement for relinquishing undeveloped areas;

proof of adequate development as a prerequisite to renewal of a block; and forfeiture of a block for failure to produce for a specified period of time.

It is however against the interest of the State and the operator that the concession terminate at the end of a fixed period of time with the expectation that some one else will succeed him. This is against the interest of the State because the concessionaire is put under economic pressure to "high grade" the mine, or produce at the maximum rate regardless of optimal rate, knowing that he will lose what he leaves in the ground. It is against the interest of the concessionaire because the shorter the tenure the less the value of his leasehold for any purpose. It is essential from the State's view point that adequate conservation practices be enforced.

Financial Provisions or Revenues to the State. The State's usual role in the mineral industry is that of a tax collector and as royalty owner. Nowadays the State is increasingly participating as a working interest.

Taxes. The wise law is said to consolidate most, if not all, levies into a single tax on net income, and recognizes that a large part of the proceeds of a mine is not income at all but a return of capital and this segment of the proceeds should not be subject to

income tax. Capital must be attracted for the risky mining business in competition with investments that involve very little risk, but which in many undeveloped countries, nevertheless pay high rates of return. Tax incentives are an important inducement. If the tax is primarily contingent on the miner's success, that is on income from a profitable production, and if the State is willing to share the gamble that the miner must take, then the gamble is more attractive than if the investor is to be subject to ad valorem taxes on the plant and equipment which represent the investment that he has gambled.

Bonus and royalties. A royalty denotes money paid to any landowner, public or private, who grants a right to work minerals which he owns. A bonus represents a fixed amount, payable once only, to the landowner on his execution of the document of title. Royalty is usually a percentage of the value of mineral produced at the point of shipment, essentially a tax on gross income.

State participation. One of the latest developments in the mineral field is the participation of government as equity holder. Some times this takes the form of outright grant of stock, free of charge to the sovereign; sometimes it is in the form of option to buy stock; sometimes it comes from the reimbursement of part of exploration expense, or in some cases it takes the form of a joint

venture between a State corporation and a privately owned one. A final option is direct involvement through a government enterprise, which becomes a direct instrument for mineral development, or a means for acquiring participation interest in a foreign company through joint ventures or stock purchase.

Settlement of Disputes. The last element of the Model Mineral Development Law is the fair settlement of disputes. Before a mining company makes an investment in a distant and undeveloped country in which that investment must remain for a very long time, it requires some reassurance that the disagreements which will inevitably arise during that protracted period will be fairly resolved by an impartial judiciary. The problem is to find a mutually acceptable mechanism for resolving disputes between the host government and the foreign private investors. Three principal ways have been found by less developed countries to reassure an investor of the safety of his long term investment. First and most important is the existence of an established judicial system with reputation for fairness. Second is by concillation through mediators. Third is by arbitration. The last concept has found expression in the "Convention on the Settlement of Investment Disputes between States and Nationals of Other States" which was negotiated under the auspices of the International Bank for Reconstruction and Development and has been signed by 62 States.

The preceding statements show that a state which seeks to develop its mineral resources has a variety of options from a broad spectrum of policy choices. Despite the infinite combinations of policy choices the central thesis of successful mineral laws the world over is fair play. If it is present the law can be implemented through any number of mechanisms; otherwise the words are hollow and the law fails to achieve its purpose.

#### The Canadian Mineral Development Formula

It is of interest to quote here the highly successful Canadian formula for mineral development as reported by W. Keith Buch, chief of Canada's Mineral Resources Division to a U.N. conference:

"(1) Security of land tenure. At each stage of exploration, development and production, the rules of the game must be clearly defined and constantly and impartially implemented."

"(2) Generous disposition of mineral rights. Mineral exploration has a high element of risk. The taking of this risk should be made as attractive as possible. The economic return to the nation can be obtained at a later stage."

"(3) The granting of tax incentives. In Canadian experience this is the main ingredient. It consists of:

- (a) a three-year tax exempt period of new mines;
- (b) a 33 1/2 depletion allowance, in perpetuity;

- (c) a provision permitting recovery of exploration and reproduction expenses;
- (d) freedom from capital gains tax;
- (e) special excise tax and customs tariff provision for mining equipment;
- (f) generous depreciation allowances;
- (g) incentives for further processing;
- (h) other special tax inducements as circumstances warrant from time to time."

"All these provide permissive recovery of capital investment, giving recognition to the intrinsic risks of mineral development. In principle, also, they could provide insurance against the changing attitude of changing governments."

This Canadian formula for mineral development is a concrete illustration of parts of the Model we are discussing. A similar formula was also applied in the successful development of the Australian mineral industry (King, R.W.L., 1969).

U.S. Land Management Law: The Framework  
of Mineral Development

This review is based on the work of Dempsey, S. (1972). Mining law encompasses rules concerning the ownership of mines and the relationship between miners and other users of lands, along with the enforcement of such rules by the State. The rights and duties embodied in these rules comprise the framework for mineral development.

Broad categories of mining rules are: (1) rules permitting private parties to acquire for mining purposes land owned by the State; (2) rules providing for the resolution of disputes between rival claimants where lands of a state are available for acquisition on non-exclusive basics; (3) rules concerning the conduct of exploration and mining on lands where the minerals and surface estates are owned by different parties; (4) rules dealing with the impact exploration and mining may have on adjoining lands which are owned by others; (5) rules dealing with the impacts of land use on the public at large; and, (6) rules discouraging wastes of resources.

The primary reason for the success of U.S. Mineral Law in developing a vigorous mineral industry during the last century is attributed to their enforcement by the reasonably efficient and fair judicial system. Although the laws originated from Congress other laws were developed by the courts and executive bodies that dealt with minerals. Another factor that contributed to successful mineral development was the legal framework which permitted the development of the mineral industry by the private sector.

Several important goals of government are embodied in the Mineral Laws: First, they are used to generate revenue to support government. Second, they promoted regional development. Areas in the West, for instance, were initially developed on account of their

rich mineral resources such as California and Nevada. Third, mineral laws were also used to realize certain strategic objectives such as the conservation of war materials.

The laws are dynamic and they change according to changing perceptions about the value of minerals to national welfare.

Under the existing framework the mineral requirements of the country must be supplied. However, a number of developments make this goal difficult to attain. The withdrawal of public lands from operation of mineral disposal laws have created problems for mineral explorers and producers. The closure of public lands make it difficult to assure that mineral goals will be achieved with domestic production. For instance, lands containing valuable deposits of uranium and oil shale have been withdrawn from disposal, hampering private development of these resources.

The National Environmental Policy Act is having enormous impact upon public land management and disposal. This act which is based upon sound environmental policy goals has become the basis of severe disruption of mineral producing activities. The environmental impact statement provision of this act and its enforcement by the courts has disrupted major mineral projects as the well known Alaska pipeline and Louisiana off-shore oil and gas base sale indicated.

Confusion in the laws governing mineral reflect confusion in policies. To achieve the mineral objectives of the country, the confused policies must be rectified. First, it might be necessary to apply some dominant use theory in the formulation of mineral policy and laws. Unnecessary restrictions on exploration and mining must be eliminated. The Public Land Law Review Commission, for example, came to the conclusion that mineral exploration and development should have a preference over some or all other uses on much of public land. In urban areas where gravel and sand supplier are becoming scarce there is an emerging comprehension of the need for protection of sand and gravel deposits from urban development.

In the environmental field, the U.S. is also facing some tough choices. It is believe that after going to some extreme, environmental standards will be made economically tolerable. To support its mineral based economy the U.S. may be forced to make a choice between conservation (wise use) and preservation (abstinence).

Another point that may be raised towards rationalizing the existing legal framework is: land tenure must not be used to accomplish other policy goals. For instance, there is now the attempt to make land tenure conditional to environmental compliance.

Conditions threatening tenure diminishes the value of the mineral property and make it difficult to secure financing for development. There are many other ways to achieve environmental goals without affecting security of tenure.

Finally, fragmentation of policies and confusion in their enforcement due to the proliferation of agencies must be remedied. This situation prevent the achievement of the goals of mineral development and instead lead to the unnecessary dissipation of energies which could otherwise have been harnessed for more productive efforts.

Kneese, A.V. (1976), in Natural Resources Policy 1975-1985, presented an incisive analysis of existing resource policies and concluded that they are now inconsistent, outdated and grossly over-dependent on direct regulation alongside a defective system of economic incentives. Such policies likewise fail to recognize the interdependencies among resource problems, including those of energy and environmental resources. The paper recommends reduced reliance on direct regulation, increased reliance on economic incentives, measures to cancel unfavorable distributive effects, measures to improve the competitiveness and performance of the natural resource industries and reorganization, both legislative and administrative, branches of government.

The case of the U.S.A. indicates that mineral policies even, in a highly developed country with a long tradition of vigorous mineral industry, can stand substantial improvements. Among the issues that tend to undermine mineral development are the growing concern over the environment, conservation, threat to stability of land tenure, taxation and the increasing reliance on direct regulation rather than on a system of incentives.

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PART II

THE  
DOMESTIC MINERAL  
INDUSTRY

POLICIES, STRATEGIES AND PROGRAMS  
FOR MINERAL DEVELOPMENT

Government policies are a potent and dynamic agent in shaping the course of mineral development. They sum up the prevailing views of government about the social value of minerals and provide directions to the march of development. They therefore must serve as the unifying principles in mineral development. Although the subject has been treated by various writers the following account is based on Leido, J. (1977), Caoili, A. (1978) Bureau of Mines (1978), and Fernandez, J. (1980).

Policy Objectives

Minister Jose Leido clearly stated that the ultimate goal of the Ministry of Natural Resources is the socio-economic development of the people through natural resources exploitation. In this connection he enumerated a number of policy guidelines for mineral development:

- 1) Improve socio-economic conditions of the people, widen distribution of benefits and democratization of wealth.

- 3) To promote social development;
- 4) To promote countryside development;
- 5) To increase foreign exchange earnings.
- 6) To attain self reliance in supply of important commodities; and
- 7) To strike a balance between exploitation and conservation with due consideration to environmental protection.

The listing of the policy objectives as well as the consistency is quite significant. These objectives epitomize the perception of pertinent officials views as to what the mineral industry can do well for the country. It must be recognized that only one of these policy variables can be maximized while the others either serve as constraints or are realized as the objective variable is maximized. We may ask: which of these variables can the industry maximize to achieve the most impact on the other objectives? Alternatively, are these objectives really the most appropriate?

### Problems and Strategies

The strategies of mineral development embody the policies and take into consideration the problems. Fernandez, J. (1980) identified the problems of the Philippine Mining Industry as follows:

- 1) In general, the mining industry's most pressing problem is maintaining an adequate return on investment as capital and operating costs soar;
- 2) Increasing environmental protection and pollution control regulations;
- 3) Lack of capital necessary to sustain exploration and development efforts;
- 4) Lack of domestic mineral processing facilities which restrains use of indigenous raw materials;
- 5) Lack of infrastructure facilities which holds back the expansion of existing plants;
- 6) Dependence on the economies of few countries which affects the mining sector's growth and development;
- 7) Lack of geologic baseline data which impedes exploration activities; and

- 8) Lack of skilled and semi-skilled workers needed by the industry.

In a broad way these problems very well represent the difficulties faced by the industry. In another sense the problems as stated are too broad, hence vague and ill-understood to be used in designing effective policy instruments to solve them. Some of these problems appear overstated, others understated. In any case, much need to be done in order to understand the nature and magnitude of effects on mineral and ultimately national development and growth.

Guided by policies and cognizant of the problems the following strategies have been adopted to promote mineral developments. Fernandez, J. (1980).

- 1) Acceleration of geologic surveys and identification of high mineral potential areas;
- 2) Setting up of data banking system;
- 3) Provide financial incentives, technical and infrastructure supports;
- 4) Streamline administrative/bureaucratic processes;
- 5) Conduct research on identified priority areas; and

- 6) Expansion of existing technical support facilities and making them more available to end users.

In addition to the preceding strategies the Bureau of Mines (1978a) added the items below which in some cases overlap those already mentioned but more clearly articulate the desired course of action:

- 7) Development of the mineral industry is primarily the function of private enterprise, although the government provides direction as well as administrative and technical support.
- 8) Encouragement of foreign investments and joint ventures in the development of certain mineral resources.
- 9) Provision of incentives, particularly processed mineral commodities; lending facilities of DBP, PNB and Central Bank, especially to small miners, including studies of taxes and tariffs.
- 10) Provision of infrastructure support to mining operations and exports, such as feeder roads and port facilities;

- 11) Improvement of market access by diversifying markets and eliminating disincentives to exports.

Although variously put under strategy or policy objectives the following items are classified as constraints to mineral development by the writer:

- 1) Minimization or elimination of pollution or environmental protection; and
- 2) Conservation.

The variety of these strategies will certainly lead to conflicts. For instance, considering the limited resources available one may ask, which should take precedence, provision of infrastructure and related incentives to the industry or the setting up of data banks? Or how should mapping and survey activities be prioritized? Granted some criteria of priority, how do we know if they lead to the best solutions for solving the industry problems or achieving social goals? We may further ask, to what extent should any given strategy be employed or a constraint applied? And finally, what pitfalls are there in applying a specific strategy, such as the opening up of lending facilities such as the DEP, and PNE, to mining firms both small or big? The motives of a strategy or policy may be good but the impact to society may be catastrophic if not properly guided!

### Programs and Projects

The Mineral Development Plan is envisioned to reach the following targets (Bureau of Mines, 1978a):

- 1) Increase contribution to gross domestic product so that by 1982 mineral contribution will be about 2.8 percent instead of the usual two or lower. This requires an annual growth rate of 13.3 percent during 1978-1983.
- 2) Total export earnings of the country is planned to grow by 23.8 percent annually during 1978-1983.
- 3) Employment in mining is expected to increase from 70,000 in 1977 to 80,000 in 1983.
- 4) The development of mining communities are expected to occur during the period where country side development will be promoted by the establishment of roads, ports, communication system, power and cottage industries, among others.

As to program, two are identified by the Bureau of Mines (1978a): First, during 1978-1983, six copper and two gold projects

are expected to come on streams. Secondly, metal based projects such as the copper smelter, iron and steel mills, and alumina smelting facilities, among others, are also expected to rise during the period.

Fernandez, J (1980) enumerated ten programs which are aimed at implementing the policies according to the strategies stated earlier. Their titles are:

- 1) Geologic Data and Mineral Lands Management System
- 2) Geologic Survey Program
- 3) Offshore Mineral Surveys Program
- 4) Research Program
- 5) Manpower Development Program
- 6) Equipment Acquisition Program
- 7) Institutional Restructuring Program
- 8) Mineral Resources Incentives Program
- 9) Environmental Protection Program
- 10) Infrastructure Development Program.

These titles are partly self-explanatory but the details are spelled out in the source.

The bureau of Mines (1978a) list down a great variety of specific activities exceeding 190 items. More than 95 per cent of these activities are technical, directed at the inventory of mineral resources.

The rest pertain to environmental activities and on the social aspects of mining which are barely implemented due to lack of personnel.

#### STATUS AND PROBLEMS OF MINERAL DEVELOPMENT

Researches on the domestic mineral industry are here viewed from the framework of the industry's development. In effect, the researches are examined as they provide information on the development variables discussed in an earlier chapter. There is an uneven distribution of researches among the development variables, perhaps, reflecting the developing state of the country rather than irrational behavior. For instance, out of 125 titles we examined 37.6 percent were associated with mineral endowment, 20.8 percent with technology, 13.6 percent touched on the global economic environment, 23.2 percent dealt with domestic environment and 4.8 percent focused on investments. Considerable gaps in information are apparent even as the most heavily researched areas show abundant inadequacies.

#### Factor Endowment

As indicated earlier this consists of variables without which no mineral industry can occur. They may be called geological, institutional and human resources.

The bulk of mineral researches deals with the generation of basic geologic information which serves as valuable input to the various stages of the mineral industry. Such information likewise becomes the basis for estimating the mineral resources of the country. They come in the form of maps, geological papers of various kinds, and tables. These works may be seen in the bibliographies of geological literature (Aquino, B., 1974; Aquino, B. and L.G. Santos, 1971; Bureau of Mines, 1979; Teves, J.S., 1953).

Examples of works mentioned above are the various geologic maps, mineral maps, and tectonic maps, papers on the geology of various areas in the country; and assessment of reserves and resources of mineral commodities like coal, copper, iron, chromite, silica, dolomite and limestone, in places like Kalinga-Apayao, Benguet or Surigao. (Bureau of Mines, 1969; Mendeleev, D., 1976; Kintanar, A. and T.W. Luna, 1976). Some of the important information from these works are given in summaries (Bacuta, G.C., 1979; Philippine Republic, 1975; and Ministry of Natural Resources, 1979).

Areas covered by reconnaissance survey as of 1975 amounted to 18.13 million hectares or 60.59 percent of total land area, as of 1979, areas covered by detailed and semi-detailed surveys amounted to 1.75 million hectares, or 5.85 percent of the country's total land area, while those areas granted leases amounted to 180,290 hectares,

Table 4  
Types of Maps Prepared by the Bureau of Mines

Name of Map	Scale	Date of Publication	Coverage	Remarks
1. Geological Map of the Philippines	1:1,000,000	1968	entire Phil.	8 sheets/set
2. Mineral Distribution Map of the Philippines	1:2,500,000	1973	entire Phil.	
3. Geology & Mineral Resources Map of the Philippines	1:250,000	1974 present	by provinces	Reports of Investigation
4. Geologic Map of the Philippines	1:5,000,000	1976	entire Phil.	in tracing paper, ready for printing
5. Structural/Tectonic Map of the Philippines	1:5,000,000	1976	entire Phil.	
6. Mineral Maps of the Philippines	1:1,500,000	1973	entire Phil.	base map PCGS using polyconic projections unpublished maps
a. Copper - 1974				
b. Iron - 1974				
c. Coal - 1976				
d. Chromite - 1976				
e. Gold - 1976				
f. Manganese - 1976				
g. Other metallic ore deposits - 1976				
h. non-metallic deposits - 1976				
7. ERTS-1 Photomosaic of the Philippines	1:1,000,000		entire Phil.	dates taken Oct. 72-Nov 73 accomplishment
8. Geologic Map (Coast lines)	1:50,000	as of Sept. '80	1. Eastern Surigao del Norte 2. Leyte 3. Negros	100% 80% 80%

Name of Map	Scale	Date of Publication	Coverage	Remarks
9. Geologic Map-Land sat Interpretation	1:50,000	as of Sept. '80	1. Ilocos Norte 2. Central Luzon	100% 80%
10. Magnetic Intensity Map	1:250,000	- do -	Samar	100%
11. Residual Map	1:250,000	- do -	Mindoro	100%
12. Normal Running Average Map	1:250,000	- do -	Mindoro	100%
13. Second Vertical Derivative Map	1:250,000	- do -	Mindoro	20%
14. Simple Bouguer Map	1:250,000	- do -	Mindoro	50%

Source: Basic data from Philippine Bureau of Mines.

or only 0.60 percent of the country's land area. Estimates of known and discoverable resources were also made for copper, gold, nickel, iron manganese and other minerals. (See Table 4).

Considering the small proportion of areas which have undergone semi-detailed and detailed surveys, much have yet to be surveyed. In fact, systematic geologic, geochemical and geophysical studies have yet to be done to cover the need for quality geologic information which remain sorely inadequate (Tupas, 1977; Austria, 1977a). Expansion of the economic zone offshore has further magnified the basic works that must be done.

Researches concerning our institutional and human resources are scarce. Suffice it to say that we have the basic legal and bureaucratic framework (e.g. Commonwealth Act 137, P.D. 463; Bureau of Mines) without which the mineral industry cannot thrive. We also have a body of skilled manpower on which the industry depends, a fact generally taken for granted but which was strongly felt at the time when the industry had to import foreign miners abroad (Santos, T.M. and D.C. Salita, 1980). We even have a number of schools which produce geologists, mining engineers, metallurgists (Sonido, E., 1977). Undoubtedly, our existing institutions and manpower are still inadequate in quality and quantity and studies are desirable in order to understand how they can contribute further to mineral development.

### Technology

Being an international industry, mining must make use of the most efficient technology to remain competitive. But because the generation of mining technology is beyond the means of a developing country new technology must be imported and adopted for the various stages of mining. Even here the proper choice and costs of technology is a difficult problem (Fupas, M.H. 1977). Austria, B (1976b) pointed out the numerous technologies that enter in the various stages of the mineral industry. Studies mainly of adaptation to local conditions can be seen in various bibliographies (Aquino, B., 1974; Aquino, B and L.G. Santos, 1971, Bureau of Mines, 1978b; 1978c.) In certain situations it is imperative to develop technologies locally to suit the peculiarity of our materials. For instance, such studies must be done to make economic the extraction of our vast lateritic iron ore resources, and to apply direct reduction technology to produce iron out of local materials (e.g., Weir, R.D., 1977; San Miguel, A.F. Jr.; L.C. Pedron; C.R. Sison, 1962; San Miguel, A.F. Jr.; I.O Pedron; G.C. Magkawas, 1963).

The effect of some technologies on the industry can be very profound (Santos, T.M. and D.C. Salita, 1990). For instance, the revolution in bulk shipping and the discovery of huge, low cost iron ores in places like Australia, India, and Brazil made Philippine direct

shipping iron ores non-competitive in the world market during the 1960s only to resurrect in the 1970s when pelletizing technology was perfected making magnetite sands economic. Again, the adoption of open pit mining technology to copper extraction completely changed the structure of this industry and brought it to an eminent position among world producers. Many technologies and changes that could affect the domestic industry are emerging without their implications being understood. The new energy situation, mining of sea nodules, hydrometallurgy, electronic data processing, among others, are forces which will affect mineral technology and development and their effects on the local industry must be understood.

Researchers appreciate the inadequacy of research activities in the country which may be due to inadequate facilities, few qualified researchers, and inadequate incentives (Punongbayan, 1979).

A large body of researches done by the industry are presumably kept in confidential files. These must pertain undoubtedly to exploration, development, mining and milling.

## Global Economic Environment

Developments in various parts of the world affect the domestic mineral industry both in the long term and in the short term. Factors that expand global demand generally favor the local industry while those that expand supply adversely affect it. Since the local industry has to sell in the world market it must remain competitive. Access to markets of various countries may be critical especially in obtaining a fair price for the local mineral. The movement of prices affect revenues and may influence profits and investments. In short, all factors affecting the world mineral market invariably affect the domestic industry. Although there seem to be general that global events affect the local industry, in-depth research is apparently wanting.

Some of the effects of global events may be culled from the work of Santos, T.M. and D.C. Salita (1980). The rapid growth of the local gold industry in the 1930s was a response to the increase in gold price from \$20.67 to \$35.00 per ounce. However, the deterioration of the primary gold industry since the 1950s resulted from the decline in real price since nominal price was officially pegged at \$35.00 per ounce. The decision of the U.S. Government to let gold seek its own price level in the market during the 1970s was predicted to stimulate the growth of the local primary gold industry. With respect to copper, its rapid growth during the 1960s and 1970s was ascribed to

among others, the rapid growth of the Japanese economy as well as to the expansion in demand due to the Korean and Vietnam wars.

Expectations about the political developments in Southern Africa have apparently boosted the local exploration and development of chromite deposits, since Southern Africa is a major producer and uncertainty about its political future makes consumers look for alternative sources. In nickel, the entry of other producers in Australia, New Caledonia, Indonesia and the Philippines has broken the control on price by International Nickel of Canada resulting in depressed prices.

Some studies noted that the dependence of the local copper industry on the Japanese market gives the latter considerable market power which permitted them to secure favorable terms at the expense of the local copper industry. For instance, cutback on copper purchase has been resorted to during times of slack demand with serious consequences to the local industry. (Dy, R. and J. Estanislao, 1972; CRC, 1973; Martinez, B. 1975).

A great variety of global issues affecting the mineral industry must be studied in the context of local industry. For instance, under what terms should government to government copper sales be contracted? What affects would joining the CIPEC (organization of copper producing countries) have on the industry?

Why do we need to import iron ores when we have considerable reserves? What are the effects of high energy costs and high taxes on the industry's ability to compete? In the plans to produce metallic copper, aluminum and steel, what problems do we expect to encounter that may hamper the success of these projects? How do we stabilize or maximize export earnings from minerals? Finally, how will supply and demand shape up in the coming years and how will this affect our market shares?

The study of the global economic environment affecting mineral supply, demand, prices and availability is a serious business which governments like those of the US, USSR, UK, Japan, W. Germany, France, Canada, among others, find important to undertake. This is so because in minerals, their industrial prosperity and even national survival may depend, to a large extent. Undertaking similar researches will undoubtedly confer considerable benefits to the country.

#### Domestic Environment

The domestic environment refers to the sum total of economic, social and political factors which ultimately determine policies. With respect to the mineral industry, its value to society, be it actual or perceived, determines the environment that breeds mineral policies, given the existing political situation.

Despite the paucity of policy related researches, almost every writer dealing with minerals has something to say about what good or harm they do and what should be done to them. Some of the important works that may be consulted on the subject are those of Medalla, F. (1977); Medalla F. and M. Pefiangco, 1977, CRC, 1974, CRC, 1973; Dy, R.T. and J. Estanislao, 1972; Esguerra, F.B., 1969; Fernandez, J.C., 1980; Rañoa, E.F., 1969; Santos, T.M. and D.C. Salita, 1980; Soncuya, C. and P. Lo, 1980; Gonzales, S.L., 1979; Leido, J. Jr., 1977; Caoili, A., 1978; Bureau of Mines, 1978a; Agawin, L. and H. Oliva, 1979; MIRDC, 1976; MIRDC, 1974; including the various laws governing minerals. These works either analyze or state the benefits or bad from the industry, what the industry should do or could do, and what should be done to promote its development or check the bad it brings.

Most writers acknowledge the important role of the mineral industry as a foreign exchange earner. Minister Leido (1977) recognized this role when he said that the mineral industry plays a "pivotal role in national development" by providing badly needed foreign exchange. The industry is also cited as an important source of tax revenues, a provider for job opportunities and a contributor to national production. All these are acknowledged in the works cited above.

Further processing of the metals by producing metallic copper, nickel, aluminum and steel is also perceived as an important step towards the industrialization of the country, as such metals become the raw materials for raw-material-starved domestic metal based industries, in addition to realizing higher value added and enhancing the goal of market diversification (Ronquillo, B. 1978; MIRDC, 1974; MIRDC, 1976; Estabillo, R., 1979; Caoili, A. A., 1978; Bureau of Mines, 1978a).

No less important but less prominently known is the fact that mining operations contribute to rural development only in providing employment, tax revenues, social services such as hospital, school, manpower training, and most important an "environment that conduces to development" (Soncuya, C. and Lo, P. 1980; Bureau of Mines, 1980a, Gonzales, S. 1979). In recognition of this, some government agencies seek to establish baseline information on the socio-economic impact of mining (Bureau of Mines, 1980a) and in fact specifies that the industry should contribute to regional and rural development (Bureau of Mines, 1978a; Fernandez, J., 1980).

The perceived value of the industry leads to the view, at least of some quarters, that the development of the mineral industry must be encouraged as evidenced in tax and other types of incentives like tax exemptions, subsidy, and planned construction of infrastructure in

mineralized areas (Gozon, B., 1950; Guzman, S.T.J Jr. and G. Esguerra, 1969; Roa, C.G., 1969; Fernandez, J., 1980; Bureau of Mines, 1978a; RP, Dept. of Finance, 1973; Destreza, C. 1979).

Notwithstanding the benefits, the industry is also recognized as responsible for environmental degradation and pollution and that it depletes nonrenewable minerals to the detriment of the future generations. (Bureau of Mines, 1980b; Bureau of Mines, 1978a; Medalla, F., 1977; Bureau of Mines, 1980c. Caoili, A., 1978; Zamora, P.J., 1980). Consequently, measures to alleviate ecological damage, reduce pollution, and penalize polluters and compensate victims have surfaced.

There is also the perception in some quarters that the mineral industry is a "pampered industry". Deputy Minister Aguenza captured this view when he said "...I think the mineral industry is one of the most awarded industries in the country in terms of incentives. I don't think the government can give more than what the industry is getting now, nor will the cabinet, the NEDA or Minister Virate be predisposed to grant additional incentives for the mining industry," (Punongbayan, R., 1979). This attitude most likely result from the view that the mining industry is mainly owned by rich people. Government officials, however, are keen at providing incentives to small miners. (Business Day, Nov. 27, 1980, Bureau of Mines, 1978a; Comsti, F.A. and F.M. Relova, 1976).

Increasingly, the processing of ores into useable metals rather than concentrates is becoming a desirable social goal for several reasons. First, further processing permits the production of more values out of the same unit of ore. Second, this will allow more flexibility in marketing since even developing countries can use the refined metal thus lessening dependence upon very few developed countries. Third, substantial savings on costs of transportation can be realized. But the most important reason is the conviction that metal processing will lead to the emergence of other industries such as the fertilizer, electrical and metal fabrication which will lead to the industrialization of the country. As a matter of fact, there is already the framework for a modest ferrous and non-ferrous metal fabricating industry which depends upon highly variable imported raw materials. Though private gains may be minimal in processing (about 6.0 percent return on investment for copper smelter) the social returns may be substantial. (Alonzo-Capistrano, A.Z., 1969; Dy, R.T. and J. Estanislao, 1972; Estabillo, R., 1977; MIRDC, 1976; MIRDC, 1974; Puyat, O., 1976; Ronquillo, E. 1978)..

## Investments

Investments are a crucial problem in the mineral industry because without them mineral production is not possible. Given possible sources, investments may be committed only if there is a better chance of making profits at reasonable risks than elsewhere. We therefore focus here on studies that deal with the system of incentives and disincentives which in the ultimate analysis determines the profitability and risk of a mineral venture.

Money raised from domestic sources such as the stock market and banks, among others, represent but a small portion of investments in mining. Long term and medium term foreign equity may be available (Santillan, T., 1977, Herrera, R., 1977; Tsuda, M. 1978).

## Incentives

Cognizant of the need for foreign investments, the government has adopted a "policy of encouragement and attraction" with respect to preferred areas of investments, as expressed for instance in the Export Incentives Act (RA 6135) and Investment Act (RA 5136) which guarantee foreign investors the opportunity to recover their investments, earn reasonable profits and repatriate them (Lava, H.C., n.d.). More specifically, and the Mineral Development Act of 1974 (P.D. 463), as

amended, has provided a mechanism whereby a foreign firm can act as a service contractor to the government or any domestic firm and earn at most 40 percent of the net proceeds before tax as fee (which may include dividends if the contractor is also a stock holder).

Considerable tax incentives are available in the mining industry which are granted by the Investment Incentives Act (RA No. 5186), and the Mineral Development Act of 1974, which include, among others, exemption from tariff duties and compensating tax on the import of equipment and spare parts and in appropriate cases, exemption from all taxes except income tax for five years. (Gison, C. n.d.; Carpio, A.T., 1977). Table 5 summarizes the important tax incentives available to mineral producers. These incentives, among others, have substantially contributed to the development of the local mineral industry during the 1960s and 1970s (Tolentino, E., 1972; Santos, T.M. and D.C. Salita, 1980).

Apart from tax exemptions cited above, other forms of incentives have also been made available to the mineral industry. For instance, the government has extended subsidy to the gold industry since 1954 through the Gold Industry Assistance Act (a system of tax reliefs), indicating the government's firm commitment to protect the industry when necessary (RP, Dept. of Finance, 1973; Comia, M.A. and C.T. Narcisa, 1979, Destreza C., 1979). More recent developments indicate

Table 5  
Specific Tax Incentives

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- A. The Investment Incentives Act (Republic Act No. 5186). This Act grants preferential tax and other benefits to registered enterprises in preferred areas, i.e. those sectors which are of crucial importance to the nation's development. Two categories are recognized, viz. preferred pioneer and preferred non-pioneer.

Incentives to Preferred Non-pioneer enterprises

1. Deduction from taxable income of all capitalized organizational and pre-operational expenses over a period of not more than 10 years from the date of operation.
2. Accelerated depreciation of fixed assets.
3. Carry-forward of net operating losses incurred in any of the first 10 years of operation for the following six years.
4. Total or partial exemption from tariff duties and compensating tax on importations of capital machinery, equipment, and spare parts, within seven years from the date of registration of the enterprise under certain conditions.
5. Tax credit equal to 100% of the value of the compensating tax and customs duties that would have been paid on machinery and equipment purchased from a domestic manufacturer had these items been imported. Another tax credit equal to 50% of such compensating tax and customs duties is given to the domestic manufacturer.

6. Credit for taxes withheld on interest payments of foreign loans if no such credit is enjoyed by the lender in his country and the registered enterprise has assumed the liability to pay the tax.
7. Deduction from taxable income of certain amounts to be determined by the Board of Investment (BOI) of undistributed profits reinvested by a registered enterprise in its capital stock for procurement or expansion of machinery and equipment used in its business.
8. Anti-dumping protection with respect to importation of goods and commodities that unfairly or unnecessarily compete with those produced by the registered enterprise.
9. Additional deduction from taxable income of 50% of expenses, but not exceeding 10% of the direct labor wage, incurred for upgrading unskilled labor.
10. Preferential treatment in the grant of government loans but this incentive can be availed of only by enterprises which are Philippine Nationals.

B. Incentives to Pioneer Enterprises

1. Exemption from all taxes under the National Internal Revenue code, except income tax on a gradually diminishing scale.
2. Post operative tariff protection to an extent not exceeding 50% of dutiable value of imported items similar to those being manufactured by the pioneer enterprises.

C. Export Incentives Granted by the Investment Incentives Act

1. A tax credit equal to the sales, compensating and specific taxes and duties paid on raw materials and supplies and in the manufacture of export products and part thereof.
2. Additional deduction from taxable income for the first five years from registration, of direct labor cost and local raw materials used in the manufacture of export products but not exceeding 25% of total revenue. However, the local raw material component of traditional exports is excluded from the allowed deduction.

- D. Incentives from the Mineral Resources Development Act of 1974
1. Exemption from all taxes, fees and other charges that may be imposed by any local governing body such as cities or provinces.
  2. Exemption from all taxes, except income tax, for a period starting from the date of exploration and ending five years from the date of commercial production on importation of machineries, equipment, supplies and materials required for the mining operations.
  3. Exemption from all taxes except income tax for the same five year period on all mining claims, improvements thereon and mineral products derived therefrom.

Source: Gison, C., n.d. Studies in International Fiscal Law: Taxation of the Extractive Industries, V.LXIIIa, pp. 459-473.

the efforts of the government to infuse public funds into the industry. For instance, the Development Bank of the Philippines has Coal Financing as well as Gold Financing Programs. In the latter, ₱100 million annually was allotted for 1975-1979 (Ampongan, A., 1977). More recently it was reported that both the Philippine National Bank and the Development Bank of the Philippines, which have already a ₱1.5 billion loan exposure in a mining company in trouble, have allotted additional ₱300 million to finance the construction of facilities (Business Day, October 6, 1980, p.7). There is also agitation to create Loan Fund for small mining (Bulletin Today, May 6, 1980, p. 25). All these indicates the growing willingness of the government to venture into the risky and capital intensive mineral industry, certainly an important area for research and policy.

Other form of incentives, among others, consists of mechanisms for facilitating the processing of applications for various mineral activities, prevention of the occurrence or speedy settlement of conflicting claims, and provision for continuity of operation despite litigation. Another form of incentives are illustrated by the effort of government to improve the quality, variety, quantity and accessibility of technical information and services and the provision for infra-structures such as roads, power facilities and ports (e.g. Bureau of Mines, 1978a; Fernandez, J., 1980).

### Constraints on Development

Despite the avowed goal of the government to hasten the growth of the mineral industry in order to help finance the ambitious national development plan, other objectives generate forces that tend to undermine the development of the industry. Such forces may be classified under (1) "problem taxes", and (2) "problem regulations".

In a nutshell, the issues against "problem taxes" are that: (1) they create an uncertain investment environment in which rational long term planning becomes impossible; and (2) they are crude in the sense that they affect both earnings and capital, both profitable and losing mines. They lead to confusion as to the real intention of the government, and to frustrations for those who have made strong commitments based on the very liberal incentives.

For convenience of reference the taxes normally paid by mining firms are summarized in Table 6. This may be used in conjunction with the table on incentives to appreciate the incentives.

The problem taxes may be illustrated by the controversy on the (1) phasing out of percentage depletion allowance (2) export tax; (3) premium tax; and (4) increased and valorem tax.

Table 6  
Taxes Payable Generally by  
the Mining Industry

A. Corporate Income Tax

For domestic corporation (incorporated under Philippine laws), the income tax rate is 25% for the first ₱100,000 of net income from world wide sources and 35% on the excess.

For resident foreign corporation, the income tax rates are the same as for the domestic corporation except that they are based on net income from Philippine operations only.

If the corporation is closely held (50% owned by or for not more than five persons) or its net income exceeds 10% of its net worth, in case of a domestic corporation, or its net assets in the Philippines, in case of a branch, an additional tax of 5% is imposed, based on the same taxable income subject to the 20-30% rates.

B. Mining Taxes

	<u>Base</u>	<u>Tax</u>
a. Leased lands		
1. Occupation fee	Per Hectare	₱2.00

2. Rentals		
Coal		
First 10 years	Per Hectare	₱5.00
After 10 years	Per Hectare	10.00
Other Mineral	Per Hectare	2.00
3. Royalties		
Coal		
	Per ton (1016kg)	Such amount stated in the lease but not less than ₱0.20
Gold		
	Actual market of gross output	1.5%
All other Minerals		
	Actual market value of annual gross output	2%
b. Mineral Lands not under lease		
Ad valorem tax		
	Actual market value of gross annual output	2% except gold which is subject to 1.5%

Source: Gison, Cornelio, Studies on International Fiscal Law: Taxation of the Extractive Industries, v. LXIIIa, pp. 459-473.

Depletion allowance basically is a device to decrease tax payment of a mining firm to replenish the fixed mineral stock which is depleted by production, a concept accepted in many countries such as the United States. It was introduced into the country's mineral law in 1960 by Republic Act No. 2698 which allowed a firm to deduct 23 percent of gross income, but not to exceed 50 percent of net income, before income tax is calculated. The depletion allowance, as conceived above, was formally revised by P.D. No. 69 and Revenue Regulation 5-76 of April 2, 1976, which set down the rules on the computation of cost depletion which essentially reduced depletion allowance to the recovery of the costs of development and exploration of a producing property, not otherwise recoverable by depreciation. More detailed discussions of the issues can be found in the literature (Carpio, A.T., 1977; Tolentino, E., 1972; Base Metals Association of the Philippines, Inc., 1972; CRC, 1973).

Imposition of Export Tax and Premium Duty was introduced by P.D. 230. It was suspended by Executive Order Nos. 434, 450, 457, 588 and later re-imposed by Executive Order No. 581. The export tax imposes 4.0 percent tax on the free-on-board (f.o.b.) value of the mineral, while the premium tax slaps a 20 percent duty on the mineral value based on the difference between actual price and a base price determined by the Bureau of Customs (Business Day, June 4, 1980, p. 1; Carpio, A.T., 1977; Business Day, Nov. 27, 1980; p. 17).

Most recent controversy on mine taxation centered on Batasang Pambansa No. 43 which increased ad valorem tax on mineral production from 1.5-2.0 percent to 5.0 percent. To soften the impact of the law P.D. 1724 was passed to give the President the power to revise tax rates, especially for marginal mines, when national interest so requires. Shorn of all verbiage, the tax was intended to raise funds in a simple (in the sense of easy to collect) way; whereas objections were based on the fact that the tax was not considered in the evaluation of the projects now operating and therefore the investors committed large investments under the assumption of more liberal tax environment. The objections are heightened by the fact that the tax will not only bite into the profits of the profitable mines, but likewise into the returning capital of marginal and sub-marginal mines. Under the situation only three out of about 240 firms will earn some profits at level that could keep them marginal (Garcia, M.A., 1980, Business Day Nov. 27, 1980 p. 17; Business day, June 4, 1980, p.1).

Aside from the "problem taxes" there are also regulations that adversely affect the mineral industry. These regulations are mainly premised on the need to protect the environment either for its own sake or for men. These consists of the (1) requirement of Environmental Impact Statement for any mineral project; (2) declaring certain areas as excluded from mineral activities; (3) requirements for arresting environmental degradation, and (4) fines to compensate victims of pollution.

The regulation that projects which tend to affect the environment should submit a formal report on such impacts and what it plans to do with them, to be approved by the Government, is mandated by P.D. No. 1151. A new decree, P.D. No. 1526, was issued in 1979 to give more teeth to P.D. No. 1151. The Environmental Impact Statement (EIS) are thought in some quarters to be expensive, difficult to prepare and bordering on the "esoteric". (Punongbayan, R., 1979). If experience of the U.S. is any indication of things to come, then this particular requirement will lead to lengthy legal battles which delay the construction of projects and costs a lot of money. Recent local experiences are pertinent. The copper smelter originally proposed for construction in San Juan Batangas and expected to come on stream in 1979 is now being constructed in Isabel, Leyte and may come on stream in 1982 because of environmental controversy, a delay of at least three years, not to mention the costs associated with the transfer and delay. Again, apprehension about the safety of the Bataan Nuclear Plant caused a delay in its construction plus a very hefty increase in costs from \$1.2 billion before the revision which included additional environmental safeguards to \$1.9 billion after.

Large tracts of land are also being closed to mineral development in form of bird and wild life sanctuaries, military reservations, tourist reserves, forest and watershed reservations. Whatever minerals

Table 7

Partial List of Government Reservations  
With Mineral Exploration Permits

Name of Gov't. Reservation	Area of Reservation	Total Area of Mining prospects/exploration
1. Central Cordillera Forest Reserve (Northern Luzon), 1929	697,138.19 has. (82,360.90 has. excluded from reservation)	43,552.42 has.
2. Sta. Cruz Reforestation Project, Zambales, 1964	7,799.64 has.	371.70 has.
3. Mt. Lingat Forest Reserve Mindoro	15,216.00 has.	7,000.00 has.
4. Talavera River Watershed Forest Reserve, Nueva Ecija and Vizcaya	37,295.35 has.	994.76 has.
5. Masbate Forest Reserve	34,487.01 has.	4,570.36 has.
6. Mt. Kabanulan Forest Reserve, Davao, 1966	20,420.00 has.	9,376.01 has.
7. Mt. Balakan Forest Reserve, Cotabato, 1967	17,298.00 has.	226.00 has.
8. Mansalay Forest Reserve, Oriental Mindoro, 1968	15,255.00 has.	5,000.00 has.
9. Kasibu Forest Reserve, Nueva Vizcaya, 1967	16,619.00 has.	4,173.00 has.
10. Dibudalan Mountain Forest Reserve, Sub-prov. of Aurora, Quezon, 1966	3,754.00 has.	2,632.71 has.

Name of Gov't. Reservation	Area of Reservation	Total Area of Mining prospects/exploration
11. Mt. Sugarloaf Forest Reserve, Zamboanga del Sur and Norte, 1966	50,173.00 has.	2,787.50 has.
12. Northern Ilocos Norte Forest Reserve	105,242.00 has.	1,753.15 has.
13. Southern Ilocos Norte Forest Reserve	22,687.70 has	
14. Katipunan-Manukan-Molave Forest Reserve	-	783.56 has.
15. Pantabangan Watershed, Nueva Ecija	-	5,103.00 has.
16. Mabini-Dasol-Infanta Forest Reserve, Pangasinan	-	1,024.45 has.
17. Magat River Forest Reserve	-	1,606.38 has.
18. Communal Forest and Reforestation Project, Benguet	-	79.98 has.
19. Abulog River Forest Reserve, Kalinga, Apayao	-	379.79 has.
20. Casiguran and Mangian Forest Reserve	-	6,239.00 has.
21. Mt. Mobanghil Forest Reserve, Zambales	-	948.31 has.
22. Southern Zambales Forest Reserve	-	572.33 has.
23. Umiray River Forest Reserve, Quezon	-	4,106.24 has.
24. Marinduque Forest Reserve	-	365.54 has.
25. Northern Mindoro Forest Reserve	-	480.42 has.

	<u>Name of Gov't. Reservation</u>	<u>Area of Reservation</u>	<u>Total Area of Mining prospects/exploration</u>
26.	Narra Agricultural Settlement, Palawan	-	3,376.08 has.
27.	Central Palawan Resettlement Project	-	14,881.34 has.
28.	Mt. Lamtotoao Forest Reserve, Davao	-	2,659.00 has.
29.	Impasugong Forest Reserve, Bukidnon	-	84.06 has.
30.	Tungawan-Malayal Forest Reserve, Zamboanga	-	2,847.72 has.

Source: Basic Data from Philippine Bureau of Mines.

are in these vast tracts of land will not be made available to society. Although parts may be later released for mining purposes, the process is difficult and lengthy (Bulletin Today, May 16, 1980, p. 25; May 19, 1980). (See Table 7).

Agawin, L. and H. Oliva (1979) investigated the effect of P.D. 1520 which declared beach areas as tourist zone, on the iron ore industry of the country. The ban on beach mining extinguished the rapidly growing magnetite sand mining resulting in the loss of about 2000 jobs, ₱93 million peso annual sales, ₱7.7 million taxes, and the transformation of all valuable minerals in the beaches, such as iron, chromite and silica into ordinary sands and pebbles. This problem is known to a number of our government officials (Caoili, A., 1978).

The government also requires the restoration of mined out areas, to their original state (P.D. 1198), or to a condition suitable for habitation, or agriculture and related activities. Abatement of tailings pollution for sometime has been in the limelight. Tailings ponds and related facilities to alleviate pollution from tailings run in the tens or even hundreds of million pesos. For instance, a project proposed by the Bureau of Mines to solve siltation due to mine tailings in the Baguio District runs in the order of ₱450 million. A new decree, P.D. No. 1251, imposed fees on pollution by private owners to compensate the victims. (Vitug, M.D., Business Day, Nov. 27, p. 19; Zamora, P.M., 1980).

Finally, mineral leases are also required to submit a work program prescribing a minimum amount of expenditure for improvement per hectare annually (e.g. ₱250/ha. for metallic deposits). It also requires that the leases take measures aimed at providing for the growth and development of any industry other than mining suitable to the people residing in the area when the mine is already exhausted (Bulletin Today, June 24, 1980, p. 20; Bureau of Mines and Geosciences, 1980c, p. 37).

The discussions under investments leave the impression that the mineral development policies are in a confused state. On the one hand, there is a set of generous incentives designed to attract investors only to be repelled by a battery of taxes and regulations that attack not only the rent but also the invested capital. Such ambivalence may be costly in the sense that the government forgoes collecting certain tax revenues hoping that the act will induce a certain level of development which may never materialize because it is discouraged by the constraints. It appears that both the regulators and the regulated are unaware that the costs of regulation are part of the social benefits along with taxes, foreign exchange earnings and employment.

SUMMARY  
CONCLUSIONS AND RECOMMENDATIONS

This review paper was designed to scan over the whole spectrum of the Philippine Mineral Industry to see where gaps in information or policy exist and to spot out problem areas. Despite the rarity of honest-to-goodness researches, especially in the field of mineral economics and policy, we think we have definitely identified voids in information as well as problems in policy. The issues we raised, including the approach and framework, must be referred to part one of this work. In fact, the conclusions and recommendations are presented in the development framework constructed in part one, or under the variables of such model.

Factor Endowment

Our assessment of research efforts indicate heavy concentration in various types of surveys, mapping, and resource inventories which have led to the accumulation of knowledge about the country's geology and mineral wealth. These efforts, along with those of the private sector, have provided the basic information for a mining sector that the country can be proud of, especially among developing countries.

Emphasis on these works have been made properly, because these are the sort of activities that should occupy government agencies since their products are public goods and private firms can not be expected to do them. Of course there are still a lot to be surveyed, mapped, studied and evaluated especially as new developments increase our economic zone, new needs require the investigation of new parameters, and new technologies suggest fresh approaches. However, there is a need to improve the quality of work being done and ensure that they will be adequate in amount and quality for rational national planning. For instance, the surveys being carried out do not contain information that is needed to measure the country's mineral resource base and the resource inventories are not of the form that is useful for national economic planning, in the sense of part one of this work.

It may be necessary to examine if the present organization of institutions dealing with the mineral industry is the best arrangement possible. More efficiency may be gained if, as some people say, the geological survey becomes detached from the regulatory functions of the Bureau of Mines.

The need for better geological schools, laboratories, and research institutes must be studied and provided for especially as the development requirements of the country expand. In particular, the need for a high caliber graduate school in the geological and mineral sciences may be urgent.

## Technology

Being an international industry, mining must use the latest or most efficient technology. By and large the private sector takes care of its technology needs. The private sector may tend to be too myopic or conservative or may not be willing to undertake certain activities with large public components.

As an old vanguard of the mineral industry suggested (A. Faretta, 1977), it may be useful if some entity continuously monitors, reviews, and publishes technological or technical changes taking place in various parts of the world. We may add, moreover, the need for studying the implications of such developments to the domestic scene.

Researches to develop our own indigenous iron, chromium, and aluminum resources must be encouraged. Again, since researches are bred in the graduate school, at least one good quality school in the geological and mineral sciences must be developed. This will also facilitate the monitoring of new developments as well as technology transfer. Finally, since a lot of mineral and geological data are gathered by private firms, such data must be submitted to the proper government entity for compilation, collation, interpretation and publication after a reasonable time. This will ensure continuous and progressive growth of mineral and geological information without

too much cost duplication. The data must be made accessible to interested investigators after a specified time.

### Global Economic Development

The developments in various parts of the world affect the domestic industries. This is amply demonstrated by the account on the expansionary effect of increased gold prices on the domestic gold industry before World War II, followed by its subsequent decline during the 1950s, 1960s and early 1970s, due to the decline in the real price of gold. Similar dependence of the local industries on world events are indicated by the cases of copper, iron, ore and chromite.

It is therefore expedient that systematic and continuing studies of the markets for various minerals be made from our point of view. The domestic industry must always be viewed as part of the world picture. The nature and extent of topics pertinent to research and policy are illustrated below.

To remain competitive the comparative advantage of the domestic mineral industry must be maintained. These require knowledge about the movement of production costs and the factors affecting them. Specifically, mineral policies and taxation must be studied; so are the costs of capital, labor, transportation, energy and environmental control.

Access to market must also be carefully studied. Considering the various stages of production, alternative markets and the barriers that must be hurdled to effect trade must be analyzed. Terms obtainable from alternative markets must be evaluated so that the best may be availed of.

Evolution of old and new markets must be analyzed to anticipate changes, mitigate their adverse effects and amplify favorable ones.

The effects of activities like joining a commodity agreement, cartel, or stockpiling upon the domestic economy must be carefully studied and evaluated.

As domestic industrialization proceeds its mineral requirements must be anticipated and alternative sources identified.

In short, studies of the world markets for the minerals we export or use, their supply, demand, prices, and availability, including forces that tend to distort market operation must be made in the context of local conditions to develop policies that enhance or protect the country's interests.

### Domestic Environment

Crucial to the development of mineral policies are the perceptions about what the industry contributes to national welfare and their costs, regardless of whether such perceptions are real or imagined, true or false. On the one hand, the role of the industry as an important foreign exchange earner is universally acknowledged. This is reinforced by contribution to government revenues, employment, and national product. Although less known, the industry also contributes significantly to rural or regional development. On the other hand, some groups think that the industry is pampered with tax exemptions and other incentives as it degrades the environment. It is also coupled with the belief, mainly false, that the industry is extremely lucrative and its profits benefit only a few wealthy stockholders. These perceptions have led to the development of mineral policies which are replete with incentives countervailed by controversial taxes and rigorous environmental rules.

Numerous issues and topics need be investigated to arrive at a more rational mineral policy. Some of the topics are illustrated below.

Given the characteristics of the mineral industry (which must be established first) what role can it do best towards national

development? Granted that such a role is identified and pursued, what other national goals may be promoted? Having identified the optimal goal, what are the alternative strategies that may be used?

Concerning the "balance" between environmental protection and development, research and debates must be done to establish where the desirable level must be, given our stage of development. We must determine the social costs (and benefits) of environmental control and decide how much we want to pay in terms of unemployment, and taxes foregone, among others. We must enquire who gets the benefits out of certain environmental measures, the poor, the rich, the tourists or Mother Nature? We must also investigate if the influx of literature, counsels and advices from developed countries serves to protect their comparative advantage vis-a-vis developing countries and at the same time make the latter market for their anti-pollution gadgets and technologies.

How does a mining firm help in the development of the community where it is cited? How may the creative and desirable contributions be amplified without much imposed requirements or regulations? How can the government harness the development energies in the mining firms to achieve regional development? How desirable or effective is the current requirement on the mining firms to develop non-mining industries?

Regarding small miners, what role in the national plan do they play? In what ways can the government help them best?

On matters of strategy, it may be useful to know under what situations should direct regulation be preferred over market operation.

#### Investments

Source of development funds is a prime problem of mining. The bulk of funds are mainly loans and partly equity from foreign sources. Domestic funds are secured from the stock market, government financial institutions and private banks, and other sources. Consequently the service contract arrangement was added to provide an additional venue for tapping foreign investments.

A system of tax incentives exist which makes the mineral industry one of the "most awarded".

However, in recent years the government has been exacting higher taxes during profitable years in the form of ad valorem tax, export tax, and premium duty. To compound the situation, a series of laws and regulations has been passed which restrict the operations of mining firms and tend to increase costs.

Consequently, the investment situation in the mineral industry has become complex with many uncertainties which may arrest its growth in the future.

Some issues and problems that may need further study are illustrated below.

Considering the costs of government requirements and regulations, is the mineral industry still the favored one it used to be? In the light of the principles reviewed in part one, what should be considered fair return on investments? If the mineral industry were treated like a public utility would it continue to grow at the usual pace? What are the implications of reduced mineral production to national welfare?

Given the ad valorem, export and premium taxes, what are their implications to mineral investments? How fair are these taxes? are they not confiscatory?

Considering the various tax incentives, by how much do they affect the value of a mine?

With regard to the various requirements and regulations it is important to evaluate their costs (benefits) both to the firm and society.

Table 8  
Mineral Research or Policy Priorities

Topic	Priority
Factor Endowment	
1. Review or Revision of Certain Plans or Activities of Government to suit the need for Socio-Economic Planning	2
2. A Study of the Need for a Geological Survey Separate from the Bureau of Mines.	4
3. The Need for Improved Geological and Mineral Schools and Laboratories.	2
4. The Need for a Strong Graduate School in the Geological and Mineral Sciences.	1
Technology	
1. Monitoring and Reviewing of Technological and Technical Advances in Various Parts of the World and Analysis of Their Implications to Domestic Industry	3
2. Development of Technologies to Harness Certain Domestic Mineral Resources (e.g. Laterite).	5
3. Mechanism for Securing, Storing, Analyzing, Synthesizing and Disseminating Mineral Data from the Private Sector	2
Global Economic Environment	
1. Comparative Study of Mineral Policies and Taxation	2
2. Study of Comparative Mineral Costs	1
3. Study of World Mineral Markets in the Context of Philippine Situation.	2

Topic	Priority
4. Study of Alternative Mineral Markets which may be Tapped for Philippine Exports or Imports	3
5. Study of Commodity Agreement, Cartel and Stockpiling of Certain Minerals and Their Possible Effects on the Domestic Industry	4
Domestic Environment	
1. Given the Characteristics of the Mineral Industry What Role can It do Best to Promote National Development?	1
2. What Mineral Strategies may be Used to Pursue the Development Goals of Government?	2
3. What are the Social Costs and Benefits of Environmental Control Relative to Mining?	1
4. Where should the Proper Balance Between Environmental Protection and Development Be?	1
5. Who Benefit from Environmental Protection More? Rich? Poor? Tourists? Mother Nature?	1
6. How Does Our Environmental Policy Affect Our Mineral Comparative Advantage?	1
7. How Does A Mining Firm Help in the Development of the Community Where it is Located?	1
8. How can the Government Harness the Development Energies in the Mining Firms to Achieve Regional Development?	2
9. What role do Small Miners Play in National Development? How can the Government Help them Best?	2
10. To What Extent, or Under What Conditions Should Direct Regulation be Preferred Over Market Mechanism?	2

Topic	Priority
<b>Investments</b>	
1. What Should be the Fair Rate of Return to Mining?	2
2. In the Light of the New Taxes and Regulations how Favored is the Mineral Industry?	2
3. Given Ad Valorem, Export and Premium Taxes, What are Their Implications to Mineral Investments? How Fair are they?	1
4. How Do Incentives and Environmental Regulation Affect the Value of a Mine	1
5. What are the Effects of Banning Large Tracts of Land From Mineral Exploration, and Exploitation on Supply?	4
6. Considering the Efforts of Government to Help in Financing the Mineral Industry, Evaluate the Soundness of the Policy.	1
7. What are the Economic Characteristics of the Mineral Industry which are Important to Policy (Elasticity of Supply, Economies of Scale, etc.)?	3
8. Study of How Environmental Regulation may be "Internalized" in the Market Process.	2
9. Trade-offs in Foreign Investments in Minerals - Pros and Cons.	3
10. An Approach Towards a Single Profit Tax-the Equivalent of Percentage Taxes and Regulation	3

### Priorities

In this final section we present a list of topics, problems, or issues which are considered important for the development of the mineral industry. By no means can we claim the list exhaustive but in any case the problems identified flow from the analyzes and discussions of this paper. Conceivably many others can be identified by going over the work. (See Table 8)

Problems identified are prioritized on the basis of urgency and scarcity of information in the area considered. In a scale of five, one has the highest priority and five the lowest.

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