U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Economic Fundamentals of Mining Law

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Open-File Report 93-0613

1993

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Introduction

New mining laws have recently been introduced, or are under consideration, in most Latin American countries. Reasons for new legislation include the desire to eliminate policies that discourage exploration and mining, the need to modernize the minerals sector of national economies, and to regulate the environmental effects of mining. Evaluation of these new laws requires criteria for ranking alternative policies capable of achieving the goals of mining law.

Although not the sole criteria for evaluating mining law, economic considerations can determine the consequences of policy choices on economic growth, public finance, and other factors used to measure social welfare. Surprisingly, the economic fundamentals of mining law are not well developed. This study, which may be considered a working paper, outlines a heuristic approach to the economics of mining law that should enable the reader to assess and compare mining laws in terms of their economic efficacy. This approach also provides a basis for the development of a formal, mathematical treatment, using the analytical tools of welfare economics, which will be the subject of future work.

All aspects of mining law are rarely codified in a single statute. To assess the mining laws of any country requires examining all provisions that impact upon the industry. These provisions, including their interactions, amount to a policy regime that, purposely or not, affects the relative long-term success of a nation's minerals industry and the national economy.

Why have a mining law?

Mineral-bearing lands are typically owned by persons other than those able and willing to explore and to develop such lands. Mining law establishes the terms under which mineral lands are traded for purposes of exploration and development. In practice, the lands themselves need not be traded, rather, the *right* to explore and mine is sufficient. Hence, we shall refer to *mineral rights* as the commodity traded, keeping in mind that the actual transactions can take the form of outright sales, options to purchase, leases, or other arrangements.

For purposes of public policy, it is necessary to ask what are the socially optimal terms for trading and developing mineral rights. From an economic perspective, these are the terms which maximize *social* gains from such trades. In essence, mining law and policy should seek maximum *net* social benefit from exploring and developing a nation's mineral endowment.

Gains from trading mineral rights depend on the prices of mineral commodities, costs of production and capital, mineral endowment, exploration efficiency, and other factors. Under competitive conditions, with many landowners and many mining firms, market forces will efficiently sort out which trades will yield the largest private gains. In the absence of market failures and external costs, including adverse environmental impacts, social gains from these trades will also be maximized.

The minerals industry is neither free from market failure nor from externalities. Although most mineral markets are highly competitive, significant exceptions occur for minerals that are costly to transport, which sometimes result in local monopolies. Divided ownership of oil and gas pools can lead to the over exploitation that normally characterizes resources shared in common. Cyclical

markets and mineral prices can render mineral resource information generated by exploration temporarily valueless and may be lost rather than retained for the next investment cycle.

The mere discovery of valuable minerals, if it cannot be concealed, yield an information externality: persons who contributed nothing to the discovery can profit from the results. Development of resources in remote areas requires infrastructure that, if supplied by the mining firm, may be used to advantage by others without having shared in the expense. Certain mining and processing methods have environmental impacts which may impose specific costs on other persons, and may create unforeseen costs to future generations.

Mining law, to maximize social gains from mining, must correct these market failures and provide for the internalization of external benefits and costs. These problems often take forms specific to individual mineral commodities, certain regions, or particular extraction technologies. There are, however, general principles that must be used in solving each particular problem. These are embodied in a policy solution based on the pragmatic use of competitive markets. Before evaluating such market-based policies, certain economic aspects of mining need to be reviewed.

Modern Exploration and Mining

Exploration and mining is an industrial process by which suitable mineralized rocks are located, extracted, and processed to produce marketable materials. In their processed and marketable form, most of these materials are in a state not found in nature. Exploration seeks to meet an existing need for raw materials by locating previously unknown resources and devising ways to process those resources into usable materials. Given that each mineral deposit

is unique as to location, configuration, and quality, exploration is research that yields new information on those unique factors, information necessary to develop a production strategy.

Geologists refer to mineralized rock that may be processed into usable materials as a *mineral resource*. Mineralized rock proven to be profitable to extract and process into usable materials is a *mineral reserve*. Exploration and development is a dynamic process by which such resources are converted into reserves. On a global scale such resources are so abundant that their ultimate exhaustion is a very distant prospect. Locally, such resources may be quite limited, and may be exhausted during the normal life of a mine.

Exploration and Mining Risk

New products can be manufactured wherever a suitable site for a factory and the necessary labor skills and infrastructure can be found. Mining can only occur where suitable mineralized rock occurs. Other resources are also site specific, such as timber and scenic areas. However, other site-specific resources are commonly more abundant than economic mineral deposits. This relative scarcity tends to magnify the opportunity cost of restricting access to mineral resources.

Exploration entails very large risks and considerable expense. Suitable mineral deposits are hard to find. Recent success rates in finding base metal deposits in Canada amount to a probability of success of 0.02 (compared to 0.06 to 0.20 for oil) at an average cost of $38 million per discovery (Bilodeau and Davidson, 1991; 1985 dollars). Thus, to find an economic mineral deposit, mining firms must investigate a very large number of potential sites.

Risks faced by mining firms also extend to processing and marketing. Mineral extraction methods developed in the laboratory may fail or perform less successfully when scaled up to normal production levels. Minerals demand and prices are characterized by extreme cyclicity. Supply is usually characterized by intense competition between many firms having no individual or collective influence on price. Mining firms attempt to compensate by continually cutting costs. Investment in cost-saving technology results in a capital-intensive industry with substantial productivity growth. Cost-saving investment has been so successful that the real price of minerals has declined substantially (U.S. Bureau of Mines, 1989) despite the decreasing quality of reserves extracted.

The ultimate market risk for a mineral producer is the introduction of a cheaper substitute or a lower-cost producer of the same mineral commodity. Individual mines, whole mineral industries, or even the better part of a small nation's mineral sector can be bankrupted by such developments. Consumers benefit from lower prices brought about by inter-material competition and the introduction of lower-cost producers. Producers can protect themselves through diversification, developing new uses for mineral commodities, and investing in cost-saving technology.

Although incremental investment in existing mines can lead to gradual increases in production, large new mines create substantial, one-time jumps in overall industry capacity. These investments, including time spent in exploration, require long lead times: up to 5 years for oil and gas, up to 20 years or more for minerals. Hence, the time required to recover capital invested, can be on the order of decades.

Effects of Risk

Having so much capital at risk for such a long time results in a very risk adverse industry. For instance, the larger mining firms do not conduct most exploration. Few firms have the resources to examine a sufficient number of prospects to ensure an acceptable probability of discovery in time to replace existing reserves. Most exploration risk is taken up by small exploration firms and individual entrepreneurs who generate prospects of interest to a mining companies. Mining companies tend to limit their exploration to the detailed examination of these prospects, some of which may be acquired for more intensive exploration.

Eventually, mining firms acquire a stock of explored prospects with proven or potential reserves, some of which will be developed today, others which will be traded or held for future development. The need to secure mineable reserves well in advance of depletion of existing mines, or of future increases in demand, leads to considerable sensitivity to issues of land tenure. The importance of land tenure is reinforced by the long lead time in development and time required for capital recovery.

Mining will not occur if the mineral and surface rights are not secure during the time required for capital recovery. Nor will production occur if the terms and conditions of those rights are not enforceable. Security of tenure and enforceability of mineral rights are absolutely necessary if private-sector mining is to occur. Tenure must be secured at the exploration stage, although it may be allowed to lapse if exploration is unsuccessful. A mineral right as a commodity has value only to the extent that it can be profitably developed. Offering a right to explore without the right to mine is as practical as selling any other commodity without the right to consume it.

Mineral industry structure is quite complex and diverse. A hundred or so mineral commodities are produced by the mining industry, each of which amounts to an industry in its own right. Some industries are dominated by small-scale mining, others consist mostly of very large mines. Some of these mines will be operated, perhaps intermittently, for centuries. Others will last but a few years. Mining laws must accommodate such industrial diversity.

Market Solution with Government Ownership of Mineral Rights

A competitive market with many mineral right owners and many mining firms should be adequately served by laws that guarantee enforceability of contracts and compensation for damages that result from market failure and externalities. In most countries, however, government is the major or sole owner of mineral rights. Although government is then a monopoly supplier of mineral rights, a competitive market for mineral rights can be created by artifice. By alienating mineral rights on demand to a large number of mining firms, these rights are effectively parceled out among many "owners." Having *de facto* private property rights, firms are then able to trade these mineral rights among themselves, to secure financing, enforce contracts, and obtain compensation if mineral rights are later condemned for public use.

The ability of governments to achieve this market solution is potentially limited by a conflict of interest between government as a landowner and government as a guardian of public welfare. As a landowner, government seeks to maximize the economic return from its lands. As a monopoly supplier of mineral lands, it may be difficult to avoid the temptation to garner excess returns by limiting supply. Government's power as a taxing authority enables it to

demand compensation for minerals extracted well in excess of what may be freely negotiated between private parties.

Short term revenue gains from monopoly practices are generally at the expense of exploration and capital-replacement necessary for a sustainable mineral industry. If the added costs cannot be passed on to the consumer, which is the usual case where firms face international competition, the industry will prove less profitable than its foreign competitors and will go into decline. Noncompetitive limitations on land availability, excess taxes or holding fees, and selective granting of mineral rights in return for special considerations are forms of rent-seeking behavior that inhibit economic growth and set a poor example for the private sector.

A government concerned about public welfare, however, seeks to maximize social benefits, and minimize costs to the public, by encouraging competition. Competition among mining firms, and between materials, insures that prices of mineral materials are minimized along with costs of production. External costs are minimized by policies that force mining firms to internalize those costs. Government would maintain a competitive market for mineral rights and would expect no greater income from mining income than would obtain if mineral rights were actually privately owned.

Creating Markets for Mineral Rights

The actual mechanics of creating a market for government-owned mineral rights have developed largely through practical experience. Governments must first designate which lands are available for exploration and development. Lands which have high-value uses incompatible with mining, such as national parks or military reservations, must be excluded. Lands with significant known mineral potential need to be protected from uses which may preempt mining.

Given the inseparability of exploration and development rights, potential land use conflicts should be resolved prior to opening lands for exploration. In general, lands should be offered for their highest-value use.

Land use planning has its limits. A private landowner with holdings measured in hundreds or thousands of hectares has a fairly manageable task of assessing suitable uses for the land. A competitive market in land sales provides price signals indicating what are the highest-value uses of land. Governments, however, may own lands and mineral rights measured in thousands of square kilometers. For a government to inventory lands of such magnitude, and rank them according to value, all in the absence of market-generated price signals, is a formidable task. Most governments lack the resources for such an inventory. When governments do have the fiscal resources, they may find that the funds required exceed the revenues that can reasonably generated from the development of those lands.

Economic development precedes the inventory of government lands in any case. Most of the basic information about the mineral potential and suitability of land for other uses is generated by private exploration and development. Yet without this information, government cannot begin to act as a prudent landowner. Governments are typically one step behind private development, first giving it sanction in law, and then attempting to curb certain excesses.

At some point governments gain sufficient information and confidence to attempt to regulate land use through zoning. Here the conflict between government as a revenue-maximizing landowner and government responsible for public welfare comes to a head. Zoning is usually a tool for avoiding externalities that arise from unbridled development and for minimizing the cost of

developing infrastructure. Zoning, in this sense, is at the expense of some short-term private gains, part of which would accrue to a government landowner. Land classification for purposes of identifying and marketing the highest value uses of lands cannot be conflated with zoning for public welfare purposes, unless that classification explicitly considered externalities and infrastructure requirements.

Governments will find it less costly to limit their land-use planning to traditional zoning functions, and encourage maximum-value use of the land by creating markets for that land. Hence, once lands are made available for mining, an open invitation to explore and develop that land is extended to bona fide exploration and mining interests, domestic and foreign. The extent of lands that may be claimed, the duration for which they held for exploration, and holding costs should be designed to facilitate good faith investment while deterring private monopolies and speculation. Lands held for exploration should be tradable and renewable as long as they are actively investigated.

Enforcing Diligence

Private landowners also demand performance on the part of persons exploring their lands. Typical private agreements include provisions specifying, in dollar amounts, the amount of exploration required to acquire rights to develop mineral properties. Governments attempt to enforce due diligence through specified annual expenditures, holding fees that increase over time, or simple time limits for holding undeveloped claims. Although some such measure is necessary to prevent speculation, and to insure that no company holds more land than it is presently able to explore, each strategy has its drawbacks.

Annual expenditure requirements bear no relation to the actual level of justified exploration. The amounts specified may be more than necessary,

leading to make work, some of which may involve unnecessary environmental disturbances. Different types of mineral deposits and mineral commodities require different levels of expenditures for their proper evaluation. Any arbitrary, standard expenditure requirement will be prejudicial to the exploration of some commodities and ineffectual in enforcing diligence in exploring others.

The amounts may also be so trivial that a firm may, at little expense, hold inactive claims indefinitely. Speculation, however, is only feasible when demand for mineral rights for a particular mineral commodity are rising. Anticipating a higher price, speculators may be willing to spend more on exploration than would those exploring elsewhere for different commodities. Thus, an expenditure requirement set to deter speculation in one region or commodity may be excessive in other instances.

Increasing holding fees and time limits eventually force the relinquishment of inactive claims. However, they are again arbitrary. The time required to explore one type of deposit, or even a particular deposit, will vary considerably. The onset of higher fees or mandatory relinquishment may be too soon in some instances and too late in others. Further, there may be legitimate reasons to delay further exploration of a property under evaluation. Economic conditions may change, forcing an industry-wide curtailment of exploration activities. Preliminary exploration results may be favorable, but a short term decline in mineral prices may force a delay in further development.

Choice of a method of enforcing diligence generally requires compromises between considerations of economic efficiency and practicality. A reasonable, pragmatic approach is to set holding costs just high enough to discourage holdings in excess of what mining and exploration concerns, large or small, are able to explore simultaneously. Time constraints on holdings will

probably be more successful in encouraging useful exploration than fees that can be paid without doing work, or assessment work requirements which may be satisfied by make work.

Once a discovery is made, diligence requirements must be modified and *de facto* property rights strengthened. Discoveries must be more fully explored at considerable expense. Although a discovery may not prove to be currently economic, firms should be able to hold and trade such discoveries in anticipation of future improvements in mineral prices or, more realistically, future cost-saving advances in extraction technology. Further, firms may need to hold undeveloped reserves for some time in anticipation of depletion of reserves at existing mines.

International Considerations

Creating a competitive market for government-owned mineral rights allows firms to decide when, where, and how much exploration to undertake in response to market forces and signals. Given that minerals competition occurs on a global scale, the response of firms to these forces may conflict with national economic development goals. Development of marginally profitable reserves in one country may be deferred in favor of developing better quality reserves elsewhere. Governments will attempt to compensate by offering tax-breaks and subsidies to make their marginal reserves more attractive. Unfortunately, comparative-advantage is difficult to offset and the subsidies may eventually exceed the benefits from earlier development of a less competitive resource. Governments might do better by investing in infrastructure, or improving labor productivity through better education, efforts which would strengthen a country's competitiveness in other sectors as well.

Foreign investment in a nations' minerals sector indicates that domestic capital is insufficient to explore and develop the mining opportunities a country offers. Foreign firms may also have a comparative advantage over domestic firms in exploration and mining management and technology. After-tax profits of mining firms will usually be repatriated, but it must be borne in mind that the capital invested in the country was also "repatriated" from somewhere else. The proportion of profits due to the host country is part of the general problem of what and how landowners are to be paid in exchange for mineral rights.

Paying for Mineral Rights

Landowners expect to compensated for granting mineral rights. This expectation is commonly expressed as a demand to be paid for the value of minerals extracted from the owners' land. Such a simple concept is, in fact, rather difficult to apply.

With the significant exception of crude oil, natural gas, and coal, very few mineral materials exist in nature in a marketable form. Processing up to the first point of sale adds value to these minerals by putting them into a usable form as an intermediate product or as a consumable. Even extraction itself adds value by putting minerals in a transportable form. A passive landowner has no claim to the value added in extraction and processing. Rather, mineral rights are sold according to the *in situ* value of the mineral reserves.

Were a landowner to discover and delineate profitable deposits of minerals at his or her own expense, these reserves could be sold for their full *in situ* value. More likely, mining firms will undertake all of the exploration, and will pay for mineral rights according to their expectations as to the type, quantity, and quality of minerals that might be profitably found and developed. Mining

firms will expect that some part of that expected value will accrue to them as value added to mineral rights through successful exploration.

Ideally, all mineral rights should have such a transparent market value. In reality, the degree of uncertainty as to the true value of as yet explored mineral rights leads to the almost universal acceptance of some form of risk-sharing between landowner and mining firm. The small probability of finding payable minerals on any given untested tract will lead mining firms to offer very little in the way of up-front payments to acquire mineral rights. Mining firms will offer a better deal if the landowner accepts payment as a share of profits or revenues from minerals that might be found and mined. The landowner would then wager a small, but certain, up-front payment on the possibility that the mining firm will find profitable minerals on his or her land.

Private landowners and mining firms engage in direct negotiations to determine the exact terms for transferring mineral rights. A very wide variety of terms are agreed to, providing a flexibility that permits optimal risk-sharing between miner and land owner, and for accommodating special geological, technical, and market conditions. Governments which own extensive mineral-bearing lands, however, will find the administrative difficulties and costs of simultaneously negotiating the price of many thousands of individual tracts impractical. Most governments set standard terms or fees that apply to all such lands, regardless of variations in their true value.

The difficulty of standard fees or terms is that they render some lands under priced and others overpriced, distorting the market for mineral rights. Government mineral rights that contain deposits of low-value minerals may be too expensive to acquire. The exploration and development of those minerals would then be limited to private mineral lands. Government mineral rights

containing high-value minerals or deposits will be a relative bargain compared to similar privately-owned rights. Competition from under priced government mineral rights will force down the price of similar privately-owned mineral rights.

Some governments seek to maintain proper market incentives and recoup the true market price of their mineral rights through public auction. Mining firms nominate lands they wish to explore, which are then periodically sold at an auction to the highest bidder. Such procedures have been successful in leasing known resources, such as coal, and in leasing large areas of known potential, such as oil and gas. For many other minerals, current levels of exploration are generally insufficient to generate a competitive market for bidding on exploration and mining rights.

This procedure has other disadvantages: it can be difficult and costly to administer and, relative to private negotiations, may introduce unusual and costly delays in the transfer of mineral rights to interested parties. Governments which own most or all mineral-bearing lands, as a monopoly supplier of those rights, are in a position to manipulate the market for mineral rights in their favor. It can be very difficult to design auction procedures that assure the public and industry that government is not withholding supply or engaging in speculation.

The greatest drawback of such auctions for many minerals is the lack of money in it. Oil, natural gas, and coal are industries extracting crude products valued in the tens of billions of dollars. The value of mineral rights for these commodities is correspondingly high. Significantly less revenue is generated by most other mineral industries. Since much of that revenue is value added in processing, the residual value of mineral rights is scarcely worth the costs of implementing an auction-based leasing system.

Where a practical, inexpensive, and efficient auction system cannot be devised, the fair market value of mineral rights simply cannot be determined let alone collected. Some form of arbitrary payment must suffice. Governments have almost universally adopted payment as a percentage of gross revenue from mining or of net income. These percentages are arbitrary, there usually being no effort to determine even the general order of magnitude of the *in situ* value of mineral rights. Practical experience has led countries to set very low percentages, or to dispense with them entirely, knowing that the value of the mineral rights will be recovered many times over through the usual corporate income tax.

Tax Policy

Mining firms are liable for payments intended to compensate governments for minerals extracted as well as the usual taxes paid by corporations. The two forms of payment may be levied in much the same way and are easily confused. In fact, taxes explicitly intended to recover the value of mineral rights may actually recover more than the true in situ value of minerals extracted, let alone the value of the mineral rights prior to exploration and development by the mining firm. This excess is a hidden tax which must be considered in evaluating the over all tax burden on the industry.

Taxes are judged according to efficiency and equity. Efficient taxes have little or no effect on the economic choices of individuals and companies taxed. Under efficient taxation, competitive markets are able to function without tax-induced distortions. Equitable taxes ensure that firms in identical circumstances pay the same amount of tax. Were taxes to be inequitable, firms with lesser tax

burdens will have a competitive advantage that bears no relation to their actual economic performance.

Mining firms are subject to two principal forms of taxation: *ad valorem* taxes on revenues generated from mining and processing, and income taxes. Taxes on corporate income are almost universal and are familiar to most persons. Although income taxes raise the minimum (after-tax) required rate of return on new investments, their effect on economic decisions of firms are relatively minor and are usually found to be reasonably efficient. Equity is achieved by taxing firms at the same marginal rate, assuming that net income can be consistently defined across industries.

Ad Valorem Taxes

The various forms of *ad valorem* taxes on revenues, including severance taxes and royalties, are assessed as a percentage of gross revenues rather than net income. In an internationally competitive mineral market, where the domestic mineral industry has no influence over prices, mining firms must absorb the full burden of a tax on gross revenue. That tax can only be paid out of profits. A tax on gross income is then an implicit tax on net income that varies with the profitability of individual firms. Two firms with identical gross revenues will pay taxes on a greater or lesser share of net income depending on relative profitability. Severance taxes and royalties are also regressive. Firms that earn relatively small profits per unit output are effectively taxed at a much higher rate than a firm that obtains abnormally high profits. Under these circumstances, a tax on gross income can *not* be characterized as equitable.

The efficiency effects of gross revenue taxes are best understood when the tax is thought of as a government mandated cut in the price of minerals. Under a 10% gross revenue tax the actual revenue per unit received by the

mining firm will be 10% less than the current market price. The gross revenue tax alters the production decisions of firms in the same way as a cut in price by raising cut-off grades and rendering marginally-profitable operations uneconomic. Under a gross revenue tax, individual mines will produce less and close earlier than under the net income tax, shrinking the tax base and reducing employment of labor and capital.

Producers on non-government lands, including foreign producers, do not pay the tax. Firms operating on private lands may pay a net or gross royalty to the landowner according to widely variable terms negotiated when mineral rights were acquired. Many, if not most, countries have switched from gross to net royalties for taxation of mineral production from government lands. Any competitor on private or foreign government lands who pays a lesser gross royalty, or no gross royalty at all, receives a greater or even full price for minerals sold. With this competitive advantage, such producers are best able to make up for lost production from lands subject to gross royalties and will experience more rapid development of their mineral reserves. The global impact of a domestic gross revenue tax is an increase in the number of mines needed to supply current demand, with the required increase provided by private and foreign producers.

The greatest danger of gross revenue taxes is that normal cycles in mineral markets will result in royalty payments that exceed net income. When royalties result in confiscating implicit income tax rates, the resulting mine closures may cost the government dearly in lost taxes and resulting unemployment. Local governments will lose tax benefits as well, and significant mineral reserves will be rendered uneconomic. The contribution of the mineral

industry to economic growth likewise suffers, resulting in significant social welfare losses.

Royalties That Appear to Work

Some mineral industries which pay royalties, such as oil and coal, appear to handle the burden to no ill effect. This is in part because these industries generate unusually large differential rents and are better able to sustain a royalty. These industries are not, however, immune from the negative supply and implicit income tax effects of royalties. A study of the effect of severance taxes and royalties on the U.S. onshore petroleum industry (Deacon, 1993) found, for a wide range of price assumptions, that between 3 and 6 billion barrels of oil are uneconomic to produce on account of the tax. Those losses amount to between 4 and 11 percent of what would be produced if the equivalent amount of tax were raised solely through income taxation. The deadweight social loss, the value of production forgone net of what it would cost to produce it if profitable, is on the order of 5 billion dollars.

Differential rents occur when some deposits being mined are cheaper to develop and mine than others, given current technology. Least cost deposits, being more profitable, will be developed first. From a social point of view, this is advantageous: less capital and labor are required to extract the mineral resource, freeing up money and labor for other uses. The availability of better quality deposits, however, may be limited. Thus, deposits of varying quality, or extraction cost, may be mined at the same time. The deposits less costly to mine generate greater profits than would normally be required to justify their development.

These extra profits are differential rents which stimulate further exploration for such low-cost deposits. In theory, differential rents could be

subjected to a 100 percent tax but only at the cost of making firms indifferent between mining low-cost and high-cost deposits. As this would disrupt the optimal scheduling of resource depletion, higher-cost resources would be extracted before technology is sufficiently advanced to render them less expensive to mine.

Differential rents are inherent in oil and natural gas industries because the costs of pumping a few hundred thousand barrels of oil from a well are only marginally greater than the cost of pumping one hundred barrels a day. Introduction of cost-saving extraction technology changes nothing as all producers are capable of using the same technology. Mineral extraction is a far more complex affair, where cost-saving technology can often be used to make high-cost mines more competitive. The dynamics of most mineral industries, where low-cost resources may continue to be found, substitute materials introduced, and high-cost mines rebuilt as low-cost operations, make differential rents very difficult to maintain. The opportunity to earn such rents, however transitory, is a still major incentive to cut costs through better technology and renewed exploration. A 100% rent tax in this context would tend stifle cost-saving innovation.

Royalties and severance taxes, because they are regressive taxes on income, do *not* capture rents. A flat income tax, however, would capture a share of all rents. A progressive income tax would capture a larger share of rents. An income tax that would tax away all rents would be difficult, if not impossible, to design, but is not desirable in any case. Not only must some amount of rent be left to the industry as an incentive for efficient exploration and technical innovation, but the ability of governments to reinvest rents any better than mining firms cannot be taken for granted.

From social and private points of view, tax payments as a percentage of profits are more equitable and efficient than payments based on a percentage of gross income. Income taxes are immediately compatible with existing income tax collection mechanisms. The costs and difficulties of determining the value of minerals extracted can be avoided, in full knowledge that a tax on net income will more than cover the *in situ* value of the resource and allow government to share in, without completely confiscating, any differential rents.

Although the essence of mining law is the trade in mineral rights, other important considerations, including correction for market failures and internalization of external costs must also be considered.

Market Failures

Some market failures in exploration and mining are inherent to the business, others are introduced by government ownership of mineral lands. The best known market failure occurs in oil and gas production where several individual firms extract oil and gas from a common pool. Oil and gas is so mobile in the subsurface that firms may extract oil that lie beneath other firm's lands. This is solvable by means of unitization whereby a single operator extracts the oil and gas on behalf of all firms and divides the proceeds between.

Another market failure lies in the conservation of currently uneconomic resources. At one time, byproduct natural gas from oil production was burned off because it was not profitable to build pipelines to transport that gas to market. In some jurisdictions, gas that cannot be profitably produced and sold must be stored in an underground reservoir, conserving it for eventual future use. Similarly, large quantities of mineralized rock of insufficient quality to justify processing are often mined along with rock that will be processed. These are

regarded as waste and discarded. From a social point of view these are not wastes at all, but resources to be stockpiled for the future.

Such wastes are normally regulated only from an environmental standpoint, often with requirements that they be returned to the excavations from which they came. It makes no sense, however, to expect that future resources will come from digging new mines when plenty of already mined material may be available at existing mines. Regulation of mining wastes needs to balance the long-term benefits of creating stable, non-leaking stockpiles, against short-term benefits of landscape restoration.

Loss of Exploration Information

When mineral rights are publicly owned, other market failures are introduced. The chief failure lies in the efficient distribution of exploration information. Prudent owners of mineral rights always retain the information generated by exploration of their lands, whether that exploration is done by themselves or by others. Favorable exploration results add value to mineral rights. Unfavorable results allow lands to be used for non mineral purposes without fear of preemption of future mineral development. Each time a property is evaluated the results of previous studies may be reviewed, preventing duplication of past exploration efforts.

Governments are rarely so prudent. When public land holdings are large, the costs of obtaining, compiling, and distributing such data can be substantial. It costs the government nothing, however, if the same property is explored in the same way, several times over, by different companies. Such information, however, is vital if public lands are to be efficiently managed. Nor are private landowners always prudent. Exploration information for private lands can also be lost through inattention, ignorance, and the ravages of time. Government

archiving of minerals data, although costly, can probably be shown to generate a net social benefit.

Resource Condemnation

Lands used for mining cannot, in general, be used for other purposes until reclamation is complete. Prudent land owners will restrict preemptive use of any particular tract of land to its highest value use. Certain uses, however, may not properly be considered because they are difficult to value or are valued by society in general, but not necessarily by the land owner. Adequate methods for estimating such values and including them in government land use decisions exist (Cropper and Oates, 1992). What is not usually considered in land use policy is the future value of mineral resources that are not currently economic to mine.

This problem frequently occurs in rapidly growing urban areas where sand and gravel mines and resources are literally overrun by development (Roberts and others, 1966). Sand and gravel is a basic raw material for urban growth (roads, fill, concrete, etc.) which is quite expensive to transport over long distances. Local resources of sand and gravel are limited, thus, if a significant portion of this resource is condemned by development, sand and gravel must be imported from elsewhere at considerable expense, driving up construction costs.

The added future social cost of importing sand and gravel is not accounted for in land sales: lands containing sand and gravel resources are worth more today as urban real estate than as a mining property. Presumably, when sand and gravel resources are imported, the value of built-over resources would rise, stimulating the redevelopment of those lands for mining. This, however, is not likely. These lands are typically divided amongst many residential and business owners who individually and collectively are unlikely to

sell their properties and move elsewhere. Nor is it likely that the increased value of the mineral resource will exceed the value of surface lands already developed for other purposes.

Usually cities have plenty of room to grow. A strong zoning law that preserves sand and gravel resources for future use would not likely alter the overall supply of land for development. Although attempts have been made to enforce such a zoning policy in some communities, political pressure from developers and persons who take up residence near existing mines (which may be noisy or unsightly) usually bring an end to local extraction of sand and gravel.

Resource condemnation may occur in many other ways. Lands may be zoned or designated for other purposes without due consideration for the future importance of known or suspected resources. Nor is there usually any periodic review process for past land-use decisions, to insure that such plans are updated in the light of new resource needs and information. Some lands may justifiably be off limits to mining if current mining methods are incompatible with the primary use of the land. Such decisions may need to be modified if new, compatible, mining methods are developed.

Certain lands, however, are essentially mineral in character. They contain significant resources which will be extracted over very long periods of time. An unusual asymmetry in many land use policies is the lack of any provision for designating or protecting those lands for their primary mineral value. Included in those lands are known, significant resources that are not currently economic to mine.

Land use policy must also place a value on prior rights. An existing, but remote mine may suddenly become controversial when transportation improvements result in increased recreational use around it. This is a problem

similar to that of building houses near an existing sand and gravel mine. In principle, recreational users who desire an unimpaired "viewshed" could buy out the mine and pay for its reclamation. In practice, a political solution is easier and less costly to the recreational user as the cost of a government mandated mine closure falls mainly upon the mine owners, their employees, and the local community.

Such an action usually constitutes a legal taking with some compensation recoverable via the courts. However, no government with any integrity should find itself the frequent subject of taking suits. Fair and practical procedures for buying out prior rights should be established and followed in all such instances. In this way at least part of the true costs of such actions become apparent to all, resulting in wiser land-use decisions.

External Costs

The most significant external costs from mining are environmental. To maximize the social return from mineral development, mining firms must account for and internalize environmental costs in their production decisions. Faced with these costs firms are better able than governments to select the most efficient mitigation approach. Cost-effective instruments for internalizing these costs include legal actions to obtain compensation for damages, taxes on pollutants, and tradable permits for allowable emissions.

There is a certain level of emissions that the environment can absorb. Reduction of pollutants below that level serves no economic purpose. Further, there are variations in the returns to pollution abatement efforts which may be mine specific. An example is acid mine drainage. A certain amount of acid drainage can be absorbed by the environment depending on the acid buffering

characteristics of the local drainage basins. Governments could auction the rights to release acid waters up to the natural absorptive capacity net of natural acid drainage.

Some mines will find it less costly to eliminate acid drainage completely than to purchase permits. Others will acquire permits according to their needs. The impact of regulation would then be equitable, as each firm will, over time be driven to spend the same amount on abatement efforts albeit with varying effectiveness. Under a more typical regulatory framework, where acid drainage might be completely outlawed, or limited to the same level for all mines, the actual economic impact of regulation would vary from firm to firm. Mines with a comparative advantage in pollution abatement will fare better than others, regardless of their competitiveness in other respects.

Reclamation

Mining will often leave surface lands in a state that renders them unsuitable for their next best economic use. Reclamation to the level required by that appropriate use is the appropriate environmental response. There are, however, added wrinkles not often recognized by public policy. Variations in the size, quality, and character of mineral deposits result in some that can be completely mined out in a single extraction campaign. Other deposits contain gradations in quality such that only a portion of the mineralized material can be extracted using current technology. Such mines will be opened and closed several times, with as much as a few decades of inactivity between operations.

Other mines may be operated purposely on an intermittent basis if demand itself is intermittent or insufficient to justify year round operations. Mines may also be shut down for extended periods during economic downturns, periods of oversupply, or to permit rebuilding or expansion of mine facilities.

Some mines, such as placer mines, may be reclaimed as mining proceeds. Other mines require ever expanding excavations. To accommodate these contingencies, complete reclamation must be required only upon ultimate exhaustion of the mineral resource.

Sometimes unreclaimed mines and quarries are suitable for other uses. Abandoned underground salt mines are used for long-term storage of oil, liquefied natural gas, and critical documents. Limestone and other quarries are used as artificial lakes for wildlife and recreational purposes. Under English mining law, no quarry may be reclaimed unless it is unsuitable for waste disposal and contains no geologic exposures of scientific importance (Honey, 1991). Standards and options for reclamation need to be more sophisticated and flexible than often envisioned to accommodate these contingencies.

Reclamation laws often require posting of a bond, establishing a trust fund, or some other type of financial guarantee to insure that reclamation will occur. Most reclamation efforts must be postponed until after mine closure when revenues from mining cease. These surety requirements insure that firms set aside sufficient funds to complete the required reclamation.

Such provisions tend to work well for short-lived mines. For mines that will operate for decades bonding may not be feasible as all the principals involved may be long dead when the mine closes. A trust fund would be more sensible but estimating reclamation costs that far in the future is difficult. The longer-lived a mine, the more likely that reclamation requirements will change. Set asides based on the original mine plan may no longer be sufficient. On the other hand, technological advances may render future reclamation much less costly resulting in excessive set asides. Given that the purpose of reclamation

bonding is to ensure funding in the event of bankruptcy, an insurance scheme might be less costly, and more efficient, than bonding or trust funds.

The tax treatment of these provisions must also be addressed. Funds set aside should in principle be deducted from current mine income, particularly if the amounts are specified by law or regulation. If they cannot be deducted until expended on reclamation, then some procedure for carrying forward the costs as a loss must be established.

It is not commonly recognized that many mineral deposits are found because they already contaminate the environment around them. Clues to the presence of valuable mineral deposits include surface exposures of rocks that contain elements regulated as contaminants, anomalous concentrations of metals in surface waters, sediments, and soils, stressed vegetation, radioactivity, and gases issuing from fractures and soils. While mining may remove part or all of the source of contamination, it cannot provide complete remediation of pre-existing problems. Reclamation standards and monitoring procedures must carefully distinguish between contamination caused by mining and any pre-mining conditions.

Reclamation and other environmental standards produce a social good that in no way transcends cost-benefit calculations. Without such considerations, scarce fiscal resources will be misallocated and funds critically needed for mitigation of the most significant environmental threats may be squandered on those of little real import. Further, pollution abatement efforts cannot escape the law of diminishing returns. There is always a point where remediation costs begin to escalate while increases in environmental benefits diminish to insignificance. Cost-effectiveness is the ultimate yardstick for all environmental standards.

Prudent landowners will want to be informed as to what a mining firm will do with their lands and will have the ultimate say in their final, post-mining disposition. Under direct negotiation this is not a particularly costly procedure so long as the number of landowners is small. A government bureaucracy following inflexible procedures is another matter. Having to deal with a succession of uncoordinated agencies at different levels of government is yet more expensive and time consuming. An efficient permitting procedure must be centralized, competent, and able to perform reviews and suggest improvements in a timely fashion.

Further, the permitting procedure must be well designed. Only information truly needed for land management should be required. Since the mining firm bears most or all of the information acquisition costs, regulators must exercise great care in setting cost-effective standards for that information. Public-hearings should have set agendas that focus on comments and suggestions from parties that will truly be affected by the project, and on incorporating solutions to problems identified in the proposed operational plan. Legal appeals should be limited to legitimate criteria, with penalties for frivolous and nuisance suits.

Abandoned Mines

In many places abandoned mines and attendant environmental problems abound. It is often proposed that current and former operators of these lands be held liable for their cleanup. Where responsible parties are still alive and able to assume even part of the mitigation costs, this is the proper approach. Responsibility must be real and not arbitrarily assigned if the polluter pays principle is to be maintained (Tilton, 1992). Even if a responsible mining company, or its successor, is identifiable, it is questionable whether today's

management, workers, and stockholders, who may be operating in an environmentally acceptable manner, can be held responsible for the decisions of their predecessors.

Where environmental impacts from mining have been irreversibly socialized, special taxes are sometimes assessed on the mining industry to pay for clean up. Responsibility for past environmental damage is much broader, however, than is represented by the modern mining industry. At one time, many hundreds of thousands of individuals undertook prospecting, placering, and other small-scale mining on their own account. Mining firms were much smaller and ownership much broader than today. Most of these firms disappeared, and their mines were exhausted, long before the consolidations that yielded today's mining industry. Further, some firms entered the industry after environmental regulations were in place. Forcing blameless parties to internalize socialized costs completely undercuts the economic incentives that internalization is intended to provide.

It should also be borne in mind that the savings accrued from externalizing environmental costs were passed on in part to the mineral consumer in the form of lower prices. Although some firms were able to capture part of those savings as an extra differential rent, lower mineral prices are clearly advantageous society as a whole. The environmental costs fell chiefly on those living near the mines, who frequently sought legislative or judicial relief. Most mines, however, were sufficiently remote that the costs have fallen on future generations that use those lands for other purposes. Current generations have inherited the costs of past mineral development and the benefits of low mineral prices. A tax on mineral consumption would more fairly generate funds needed for mitigating such damage.

Conclusions

A modern mineral policy that addresses the issues outlined in this paper would have three essential features: (i) a competitive market for mineral rights and their exploration and development would be created or maintained, including correction of market failures; (ii) payment for mineral rights, and other tax obligations, would be met by taxation of net income; and (iii) current and future external costs would be internalized at the point where they are generated. Developing and implementing such policies is not easy. This study attempts to clarify some of the issues involved, and provides some practical guidelines for evaluating policy options. Future work will broaden and deepen this analysis, and outline model policies and legislation.

Acknowledgments

Earlier versions of this paper benefited greatly from discussions with Eric Force, Emil Attanasi, John DeYoung, and Norman Page, all of the U.S. Geological Survey.

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