

UNIVERSITY OF CAPE TOWN

MINERALS POLICY AND TAXATION IN THE NEW
SOUTH AFRICA:

AN ANALYSIS OF PROPOSED ANC POLICY

A DISSERTATION SUBMITTED TO
THE FACULTY OF THE COMMERCE
IN CANDIDACY FOR THE DEGREE OF MASTER OF COMMERCE

SCHOOL OF ECONOMICS

BY

Trevor A. Smith

SMTTRE003

CAPE TOWN, SOUTH AFRICA

SEPTEMBER, 1995

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

I would like to thank my supervisor, Mr Tony Leiman, for all his patience and assistance.

I would like to dedicate this to the person who made it possible for me to attend university: Mrs S. Maynard. My thanks and deepest appreciation go to you.

The financial assistance of the Centre for Scientific Development (CSD), HSRC, South Africa, towards this study is hereby acknowledged. Opinions and conclusions expressed are those of the author and are not necessarily attributable to the CSD.

I would like to thank my supervisor, Mr Tony Leiman, for all his patience and assistance.

I would like to dedicate this to the person who made it possible for me to attend university: Mrs S. Maynard. My thanks and deepest appreciation go to you.

The financial assistance of the Centre for Scientific Development (CSD), HSRC, South Africa, towards this study is hereby acknowledged. Opinions and conclusions expressed are those of the author and are not necessarily attributable to the CSD.

<u>Contents</u>	<u>Page</u>
1. Introduction	1
1.1 Optimal extraction	1
1.2 Rents	2
1.3 Taxation	4
1.4 Sustainable development	5
1.5 Outline of the paper	6
2. Theory and literature revue chapter	8
2.1 Utopia	8
2.2 The real world	11
2.2.1 Imperfect competition	11
2.2.2 Uncertainty	12
2.3 Introducing Government	16
3. Real world tax examples	23
3.1 South Africa	23
3.1.1 Minerals background	23
3.1.2 Taxation of South African mines	24
3.1.2.1 Mining leases	25
3.1.2.2 Redemption of capital expenditure	25
3.1.2.3 Capital allowance	27
3.1.2.4 Mines other than gold and diamonds	28
3.1.2.5 Diamond mines	28
3.1.2.6 Gold mines	28
3.3 Comments	32

4. Minerals policy in the new South Africa	33
4.1 First a look at general ANC policy as it pertained to minerals	33
4.1.1 Environmental policy	33
4.1.2 Minerals policy	34
4.2 Description of proposed minerals policy	38
4.2.1 Draft environmental policy for the minerals industry	38
4.2.2 Draft policy on mining taxation	40
4.2.3 Draft policy on mineral rights	43
4.2.4 Draft policy on mineral beneficiation and domestic raw materia pricing	45
4.3 Analysis of proposed policy	46
4.3.1 Environmental policy	47
4.3.2 Mineral tax policy	49
4.3.3 Mineral rights policy	54
4.3.4 Beneficiation and domestic raw material pricing policy	56
4.4 Description of conflicts in policy and objectives	57
5. Conclusion	59
5.1 Summary of results	59
5.2 Conclusions	64
Appendix A	66
Appendix B	67
Appendix C	69
Appendix D	73
Appendix E	77
Bibliography	82

1. Introduction

Contemplation of the world's disappearing supplies of minerals, forests, and other exhaustible assets has led to demands for regulation of their exploitation. The feeling that these products are now too cheap for the good of future generations, that they are being selfishly exploited at too rapid a rate, and that in consequence of their excessive cheapness they are being produced and consumed wastefully has given rise to the conservation movement¹.

The problems that gave rise to Hotelling's seminal work do not appear to have left us, and although he furnished us with some valuable results and tools to use in the analysis of these problems, there is still much to be done to expand our understanding as economists of the factors that influence extraction and the understanding of conservationists as to what optimal extraction is. While this paper is not primarily concerned with broadening this understanding, it has of necessity brought together much of the work that underpins this area of study, and may thus be of some use to this end.

This paper's is to analyse and discuss the proposed ANC minerals policy, with particular reference to taxation. This is the subject of chapter four of this paper. Chapters two and three will lay the foundation upon which the analysis and discussion will be based, specifically, chapter two will review the theory of resource extraction, exploration and taxation, and describe a few of the important results in this field of study, while chapter three will describe some real world experiences with mineral tax systems.

The remainder of this introductory chapter will introduce the issues that this paper will be addressing, beginning with the problem of optimal extraction. Additionally, some of the terms, such as 'rent' and 'sustainable development', which will be used extensively through the rest of the paper will be defined, explained and described.

1.1 Optimal Extraction

To define optimal extraction objectively is a difficult task, even, perhaps, an impossible one. The idea of optimality is a social one, which may change as society's values and desires change. Thus what may be seen as optimal by some may seem undesirable to others, everybody has a different idea of what is best for themselves and everybody else. The idea of optimality is to maximise, the

¹ Hotelling, 1931 p137

problem is that there are a large number of variables that it may be desirable to maximise, and the choice of which of these to use in the maximisation process is purely subjective.

In the case of extraction of exhaustible resources, the idea is to find an extraction path or pattern that leads to the maximisation of some measure of welfare, either for the individual or for the community at large and future generations. It is obviously impossible to judge objectively the choice of variable or variables to be maximised, all that can be judged is whether the objectives are being achieved, and whether such achievements justify the incurred costs, however these are measured.

In order to make this sort of judgement, the economics profession has derived some benchmarks against which the effects of pursuing various policies may be measured. The one usually used in this field is the extraction path under the assumptions of profit maximisation and a full set of perfectly competitive spot and futures markets (i.e. there is no uncertainty). The effects of all policies or market inadequacies on the extraction profile are judged against this benchmark. This is the benchmark used in this paper, and it is presented at the beginning of the next chapter.

1.2 Rents

The concept of economic rent is attributable to David Ricardo, who considered the case of agricultural land. The concept as expressed by Ricardo is based upon the existence of varying grades of soil fertility. Thus highly fertile soil which affords its owner the ability to produce more cheaply than others while facing the same price for his output, generates a return in excess of the owner's opportunity cost. This is the case for 'differential rents', where the rent accrues due to differential quality or fertility. Rent arises because of the limit on the better sources of supply, because of differences in output quantities produced by equal quantities of factor inputs. The other type of rent recognised by Ricardo was 'scarcity rent', this being due to the limitation of supply. "Rent is then the difference between the product of all capital-and-labour and the product of the final dose [of inputs] at the intensive margin." [Blaug '85 p.82].

Rent forms no part of the expense of production: that is, it forms no part of those expenses of production which affect price. It is a differential gain, an excess over and above the total expenses of the more fortunate producers. Price is determined by the cost of the marginal increment. Rent is not one of the factors bearing on price, but is

the result of price. It is due to the **comparatively high price** which must be paid to bring out the total supply.²

It was proposed by Henry George that the economic rent on land is a return over and above that which is necessary to induce investment, and as such should be taxed away. It was suggested that this so called 'single tax' would, by taxing away the full amount of economic rent on land, generate sufficient revenue to allow all other levies to be dispensed with.³ The Marshallian objection to such a tax is that not only land, but all economic factors may earn rents in the short run, and that even 'differential rents' are a form of incentive, encouraging the economical use of more fertile and thus scarcer land. Also, at a practical level, there is the problem of measuring the investment made in the soil and the normal return on it.

In the case of mines, economic rent was initially considered to be similar in nature to that of agricultural land, with rents accruing to individual mines because of differences in situation and relative richness of ore, i.e. differences in ore grade. This was the way in which Gray (1914) analysed the problem of rents and the exhaustion of mineral resources.

The way it is considered today is somewhat different. The rent is not associated with differential ore grades, but is rather described more simply as the difference between selling price and cost of production including opportunity cost. Following Hotelling (1931), a mineral resource is considered as part of a portfolio of assets. Such an asset must generate a return, and by the nature of a resource stock in the ground, the only source of such a return is capital gains. A resource owner is indifferent between receiving price p (net of cost) today and price $pe^{-\delta t}$ at time t in the future, where δ is the market rate of interest. Obviously p (price net of cost) is the modern definition of rent, and the result that Hotelling arrived at was that the resource owner would choose his extraction profile in such a way as to cause the rent to rise at the rate of interest. Rent in this instance is influenced by extraction rates rather than grade differences. Another interpretation is that rent is that amount required to compensate the resource owner for the opportunity cost of not still having the ore that has been extracted available in the ground for future extraction. This is what Keynes referred to as 'user cost' in his General Theory of Employment,

² Taussig 1920 p.56 (Emphasis added)

³ Substantially similar results would be attained by the community taking possession of the land for all time and letting it to tenants for the amount of its rent, allowing the latter to keep enough to pay for all improvements and interest on them, but requiring payment of the excess. Taussig (1920) This is important as it is essentially what the ANC proposes should be done with land used for mining. The point will be discussed more fully in chapter 4.

Interest, and Money. Although Keynes was more concerned with the case of capital in general, he did use the example of a copper mine to illustrate his point.

In the case of raw materials the necessity of allowing for user cost is obvious; if a ton of copper is used up today it cannot be used to-morrow, and the value which the copper would have for the purposes of to-morrow must clearly be reckoned as part of the marginal cost.⁴

In general, when an owner of a mineral resource stock leases out the resource to be mined, an amount per ton extracted is paid to the owner to compensate him for the loss of future availability of the extracted ore. This amount has historically been called a royalty, and is a rough-and-ready means of extracting the economic rent. Over time the term royalty has come to be used synonymously with economic rent. There are thus three terms used in the literature which all refer to essentially the same thing, these are:

- 1) Royalty;
- 2) Economic rent; and
- 3) User cost.

Of these three, by far the most widely used is rent, and it is this which shall be used throughout this paper.

It is the interpretation of rent as compensation for the opportunity cost of not keeping the stock in the ground for future use that brings us to the question of taxation and also the subject of the sustainability of economic development and intergenerational equity.

1.3 Taxation

If the rent generated by extracting a resource is compensation for not having it there in the future, it begs the question, who should be compensated? i.e. who should benefit from the rents? It is generally felt that the community and future generations should be the ones to benefit from the rents accruing from the reduction in a resource stock, just as it is widely felt that the mineral wealth of a nation belongs to all the people of that nation, and in fact in most countries (South Africa is an exception) all mineral rights are held by the state on behalf of the citizens of the nation.

The state thus takes on the responsibility of extracting the economic rent by way of lease agreements and various taxes in order to use the rents to the benefit of the community at large. It is the effect of these taxes on the behaviour of those who mine the resource which is of primary

⁴ Keynes, The General Theory of Employment, Interest, and Money p. 73

interests to this paper. The State's obligation to use the extracted rents to the benefit of the community and future generations brings us to the matter of sustainable development (which, it will be shown as an aside, casts a shadow of doubt on the justification of the state in taking on this role).

1.4 Sustainable Development

Sustainable development has become something of a catchphrase in the 90's, although there is seldom any attempt to define specifically what is meant by it. The UN Commission on Economic Development (UNCED) defined sustainable development in its 1987 *Our Common Future* as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs." This does nothing to guide economic and environmental policy. Taylor (1994)

It must be noted that sustainable development need not imply economic growth! It may be used to indicate a simple change in patterns of economic activity (without growth) in order to enhance human development. Some authors [Daly 1990] even say that there cannot be such a thing as sustainable growth. The writers of *Our Common Future*, however, saw things differently and maintained that economic growth was a prerequisite of sustainable development. There is thus some rejection of the advocates for zero or even negative growth (this approach has become a minority position) such as Robert Heilbroner, Paul Ehrlich, Garrett Hardin, Barry Commoner, and Dennis and Donella Matthews. Taylor (1994)

The idea of sustainable development is interwoven with that of equity, both intergenerational and within generations. This raises questions about economic growth and income redistribution. It is here that the State is seen as having a role to play. It is argued that the state is in the best position to ensure that the principles of sustainable development are adhered to, by taxing the rents from mineral extraction and using the proceeds to ensure development for present generations and equity between generations. Hartwick's (1977) suggestion that in order to ensure sustainable development and intergenerational equity, the economic rents from exhaustible resources should be invested in reproducible capital such as machines or human capital (or exploration and research into substitutes) rather than be consumed, may be seen to raise some doubts about this argument. This is because the belief that the State can be relied on to provide for "intergenerational compensation" is open to the same public-choice criticisms as all State undertakings⁵, and there is no evidence

⁵ This point may be challenged by those who believe the state has a role to play due to the divergence between social and private discount rates. In South Africa, where the market interest rate is determined more by Reserve Bank policy than by the markets, this may be particularly true. If this market rate is "too

that the market does not make the necessary investment, even if most of the profits from mining are paid out in dividends rather than re-invested⁶. This point will be discussed further in the conclusion, i.e. in chapter five.

Of course there is implicit in the calls for sustainable development the assumption that present development patterns are unsustainable. This assumption may be challenged however, and is done so quite convincingly by Taylor (1994). It is Taylor's contention that there is little evidence to indicate that present growth and development patterns are unsustainable, and that in fact as economic growth takes place, the World's development becomes more sustainable in that future generation will inherit more natural and man made capital than any preceding generation, while present generations are similarly facing improving conditions, as indicated by higher per capita incomes and lower mortality rates. In fact, the major cause of unsustainable practices is government interference in factor and product markets. Government subsidies that undermine the price mechanism being perhaps the greatest threat to sustainability. An example of this undermining of resource prices is the subsidies on energy consumption, which in developing countries total \$230 billion annually, four times the volume of developmental assistance. Taylor (1994). Again, this matter will be discussed further in chapter four of this paper.

1.5 Outline of the paper

From here, the paper will develop as follows:-

Chapter two consists of a review of the literature on the problem of optimal extraction and to some extent exploration, and the effects of uncertainty and taxation thereupon. The chapter begins with a section on the basic results that followed from Hotelling's (1931) work. This is followed by a section on the effects of taxation on extraction and exploration.

Chapter three is a descriptive one, with the tax systems of South Africa past (and present), as well as a description of the effects of these systems on the mining industry.

As mentioned before, chapter four will consist of a description of proposed ANC minerals policy, followed by an analysis thereof based on the findings of the previous two chapters.

high", then future consumption will be discounted "too much" and there will not be enough investment from a social welfare point of view. However, as noted in appendix A, this may result in conservation of the resource and reduce the need for any intergenerational compensation. There is thus no definite social harm done by such a divergence, and the challenge is weakened.

⁶ It may be in the best interests of a *nation* to have the State take on this role to ensure that the rents are invested in such a manner as to compensate future generations of that nation, particularly if a large proportion of the rents are channelled to overseas investors via dividend payments.

Chapter five will be the conclusion of the paper, with a brief summary of findings and policy suggestions.

2. Theory and literature survey chapter

The intention of this chapter is to give a survey of the results obtained in this field of study. It will begin with a description of what may be considered the ideal extraction profile obtained by maximising the social utility of extraction over time, followed by an indication of how this compares to the case of perfect competition. This is essentially a recap. of Hotelling's proof that the perfect competition results are socially optimal under certain circumstances. This will be our benchmark for evaluating the effects of market imperfections and taxation schemes on extraction profiles.

This description of a benchmark will be followed by a section dealing with market imperfections such as market concentration, externalities and uncertainty and the effects these have on extraction profiles. The chapter will end with a section describing the effects of various taxation schemes on the mining industry and extraction and their use in addressing the problems of market imperfections in this sector.

Throughout this section, the use of control theory techniques will be used. In most of the examples given, only the results of the problem will be presented. Interested readers may find full solutions to the problems in many of the references given in the bibliography, however, Conrad and Clark (1987) in particular is suggested for an overview of the technique and solution of control problems.

2.1 Utopia

**(The benchmark of perfect competition in perfect markets,
i.e. no uncertainty, government or externalities.)**

This section seeks to give an indication of what may be considered a socially optimal depletion pattern. It will do so using a very simple model, based on the maximisation of social utility as measured by the area under the inverse demand curve. There are obviously other measures of social welfare, however the utility measure is as good as any for our purposes and is widely accepted.

The following draws from Conrad and Clark (1987)

Assume that a socially minded planner wants to deplete a resource in the socially optimum way, i.e. in our example he wishes to maximise social utility from production $q(t)$, given by the area under the inverse demand curve less the area under the marginal cost curve. To keep the example simple, assume that the cost of extracting ore depends only on the rate of extraction $q(t)$. The Variables are thus,

R = total amount of resource available

$q(t)$ = rate of extraction

$C(t) = C(q(t))$ = cost of extraction

$U(t) = U(q(t))$ = utility of extraction

$P(q(t))$ = inverse demand curve

t = time

T = time of final depletion.

δ = the constant rate of interest

The planner aims to

$$\text{maximise } \int_0^T [U(q(t)) - C(q(t))] e^{-\delta t} dt$$

$$\text{subject to } \dot{R} = -q(t)$$

$$\text{with } R(0) \text{ given and } R(t) \geq 0$$

The current value Hamiltonian is

$$H = U(q(t)) - C(q(t)) - \mu(t)q(t)$$

with first order conditions

$$\frac{\partial H}{\partial q(t)} = 0$$

$$\frac{\partial H}{\partial \mu(t)} = -q(t)$$

$$\frac{\partial H}{\partial R(t)} = \delta\mu(t) - \dot{\mu} = 0$$

which can be solved to obtain

$$U'(q(t)) - C'(q(t)) - \mu(t) = 0$$

$$\dot{\mu} = \delta\mu(t)$$

If we note that $U'(q(t)) = P(q(t)) = p(t)$, then, it can be shown that

$$\frac{d/dt (p(t) - C'(q(t)))}{p(t) - C'(q(t))} = \delta$$

which in turn implies that price net of marginal cost, or in other words the rent or royalty, rises at the rate of interest.

(This assumes that $C(q(t))$ is convex, thus implying that the first order conditions are also sufficient. That is we assume $C'(q(t)) > 0$ and $C'' > 0$, i.e. costs rising at an increasing rate.)

If we had assumed constant costs of extraction, the result above would collapse to much simpler equation easily identifiable as the well-known Hotelling's Rule,

$$\frac{p}{p} = \delta(1 - \frac{c}{p})$$

This path for price net of marginal cost, or rent, dictates the depletion path for the resource. At a superficial level, it is possible to say that given a downward sloping demand curve, to achieve increasing prices the quantity produced must fall through time.

The case for a competitive market is very similar, and as will be seen, leads to the identical result. This of course implies that a free market with perfect competition and full information, is socially optimal.

The actual function to be maximised is the following, assuming the maximisation of profits as the objective of the competitive firm,

$$\text{Max } \Pi = \int_0^T [p(t)q(t) - C(q(t))] e^{-\delta t} dt$$

$$\text{subject to } R = -q(t)$$

$$\text{with } R(0) \text{ given and } R(t) \geq 0$$

The solution to this is identical to the case for the social planner above, with the results coming directly from the first order conditions. The fact that the path for price net of marginal cost is the same in both cases, implies an identical extraction path.

2.2 The real world

In the real world of course there are a number of reasons why the market and socially optimal depletion paths may not be realised or even coincide. The reasons for the non-equality of the market and socially optimal paths are the existence of imperfect competition in resource markets, uncertainty, government intervention and externalities. The first two of these shall be discussed in this section, together with a brief mention of some interventionist government policy. Externalities shall not be discussed, except to note that they will affect the rate of extraction in so far as they cause the private marginal cost of extraction to deviate from the social marginal cost. Negative externalities would thus make extraction faster than optimal, while positive externalities would imply a slower than optimal extraction rate.

The reason the market and optimal paths may not coincide, given full certainty and no government intervention, is that the interest rate used for private investment decisions, i.e. the private interest rate, may not coincide with the social discount rate. This is a complex issue, with no agreement as to whether the private rate is in fact higher or lower than the social rate, and conflicting direct and indirect effects of the private rate differing from the social rate. The direct effect of the interest rate is to affect the path of the resource price, and thus the extraction rate, while the indirect effect is on the price of capital required to finance the mining operation. Given the uncertainty surrounding this issue, this paper will assume the private and social interest rates equal.⁷

2.2.1 Imperfect competition

Monopoly

The effects of a monopoly on resource extraction have been studied in detail, beginning with Hotelling's seminal article. The monopolist essentially faces the same maximisation problem as the competitive firm, the difference being that the monopolist is able to influence the price of his product by changing his level of output. His problem can thus be stated (using the same notation as above) as

$$\text{Max } \Pi = \int_0^T [P(q(t)) - C(q(t))] e^{-\delta t} dt$$

$$\text{subject to } \dot{R} = -q(t)$$

⁷ For a more detailed discussion of this point, refer to appendix A.

with $R(0)$ given and $R(t) \geq 0$

this can be solved as usual, and we find that the solution gives the result that marginal revenue net of marginal cost must rise at a percentage rate equal to the rate of interest. This is a similar, although slightly altered, result to those obtained above. We cannot say what the effect of this slightly altered result is on the rate of depletion, unless we know more about the nature of the demand for the resource.

The elasticity of demand can determine whether a monopolist depletes a resource more or less rapidly than his social welfare maximising or competitive counterpart. If the elasticity of demand⁸ increases as we move down the demand curve, then the monopolist will initially deplete the resource at a slower rate than is optimal. (It is this case which gives rise to the adage that the monopolist is the conservationist's friend.) If on the other hand the elasticity of demand decreases down the demand curve, the monopolist may in fact deplete the resource faster than is optimal. This situation may not be sustainable, as it implies that the rents from the resource are growing faster than the interest rate, this would raise the speculative demand for the resource, with such speculation limited only by the availability of finance. This speculation would significantly alter the demand curve. Dasgupta and Heal (1979) investigate the possibility of a demand function with alternating regions of increasing and decreasing elasticity, with the expected result of periods of alternating too fast and too slow extraction, limited of course by the effects of the above mentioned speculation.

Other forms of imperfect competition have also been studied in some depth, the results, given a demand curve with elasticity decreasing as quantity increases, are below optimum initial extraction rates. The interested reader can refer to Dasgupta and Heal (1979) for a discussion of various models of imperfectly competitive markets.

2.2.2 Uncertainty

Uncertainty is pervasive in the field of resource extraction, ranging from the uncertainty of reserves to price and demand uncertainty. The literature on this subject is quite large, with many of the works deriving results from the use of models based on Bayesian decision theory, and requiring

⁸ Note that we are referring to an inverse demand curve.

sophisticated mathematical techniques. It is beyond the scope of this paper to give more than a brief overview of the major results obtained in this field.

There are two easy ways of considering uncertainty effects on depletion. The first is to assume the existence of an Arrow-Debreu economy, with markets for every commodity in every state of the world at every date. In this sort of world, uncertainty would not affect the rate of depletion as the resource owner knows the price of his commodity at every future time, and can insure against unforeseen events. Of course this sort of economy does not exist in the real world which has only limited contingency markets.

The second easy way to account for uncertainty effects is to assume that uncertainty is absorbed into the discount rate. Thus the more uncertainty a resource owner faces, the higher will be his discount rate and the rate of depletion. Fisher (1981) suggests that this may not be an accurate reflection of the situation as different kinds of uncertainty may affect depletion rates in different ways. He then gives a review of some of the types of uncertainty faced by a resource owner and the expected effects on depletion as derived by other researchers. A summary of these results is given in tabular form in Fisher (p. 48) and is reproduced below.

Kind of uncertainty	Effect on depletion
Uncertain demand for the resource, with degree of uncertainty related to distance in time from the depletion decision	Shifts depletion towards the present.
Uncertain demand for the resource, with variation in expected returns related to quantity of output.	Shifts depletion towards the future.
Uncertainty regarding the date of event that will destroy the value of the resource to the owner (e.g., expropriation, discovery of a cheaper substitute).	Shifts depletion towards the present.
Uncertain size of resource stock. ⁹	Shifts depletion towards the future.

⁹ This is for the case where the planner is fears that the deposit may be smaller than what is expected. If on the other hand the planner is afraid that the deposit may be bigger than expected, the depletion may shift towards the present.

The above results indicate that uncertainty does not necessarily increase the rate of depletion, and it is thus not always appropriate to reflect uncertainty by an increase in the discount rate. There is also the doubt raised in the previous section about the effect of an increased discount rate: it is unclear whether the higher interest rate would speed up depletion in the long run after the negative effect of higher interest rates on investment are taken into account.¹⁰

The existence of uncertainty about future prices, and the need for some estimate of future prices in the depletion decision making process, emphasises the role of expectations in resource economics. Since expected prices influence the extraction profile, they also affect present prices. There is thus a feed back effect between expected prices and present prices. This observation leads to the definition of *elasticity of expectations*. Elasticity of expectations can be defined as the percentage change in future price divided by the percentage change in present price. In order to ensure an equilibrium price path, the elasticity of expectations must be equal to or less than one. With an elasticity greater than one, a change in expected future price will result in an explosive price cycle.

An activity which affects the expected price as well as the present price of any resource by changing the levels of uncertainty is exploration. Exploration affects prices in two ways, firstly, as suggested, it influences the level of uncertainty, and secondly it can, if successful, increase the known size of reserves. Increasing the size of reserves will of course lower prices and the deterministic, monotonically upwards sloping price path suggested by Hotelling may not be realised, but have points of falling prices as new discoveries are made. Once again, the literature in this area is vast, and this paper can do no more than give a taste of some of the results.

Exploration can be undertaken to produce additional information about known deposits, or to find new deposits. The latter may be undertaken as the level of known reserves falls and extraction costs begin to rise. The result of successful exploration for new deposits is similar in effect to new technology which makes extraction cheaper or makes alternative lower grade deposits viable. Exploration and research and development will thus be considered together and be referred to simply as exploration.

¹⁰ See appendix A.

Exploration makes it possible to augment reserves, perhaps at a faster rate than they are being depleted. The following model is due to Pindyck (1978) and presented in Conrad and Clark (1987):

Let

$$\dot{R} = f(w(t), X(t)) - q(t)$$

$$\dot{X} = f(w(t), X(t))$$

where $X(t)$ is cumulative discoveries, $w(t)$ is exploratory effort and $f(\cdot)$ is a discovery function relating new discoveries to exploratory effort and past, cumulative discoveries. It is further usually assumed that $f_w > 0$ and $f_x < 0$, i.e. that as exploration and discoveries proceed over time, it becomes more difficult to make new discoveries. Assume further that total cost of extraction per unit time is given by $C_1(R(t))q(t)$ and the cost of exploration given by $C_2(w(t))$. A competitive resource owner then takes price $p(t)$ as exogenous and attempts to maximise

$$\int_0^T [p(t)q(t) - C_1(R(t))q(t) - C_2(w(t))] e^{-\delta t} dt$$

subject to

$$\dot{R} = f(w(t), X(t)) - q(t)$$

$$\dot{X} = f(w(t), X(t))$$

$R(0), X(0)$ given

The problem has two state and two control variables, which makes the solution more difficult than the problems discussed thus far. The solution is a system of four equations in R, X, p, w , which lead to several dynamic possibilities. One possibility is that if initial reserves are high, initial exploration will be low, increasing as reserves fall. This possibility may result in a price path consistent with Hotelling's result of monotonically increasing prices. A second possibility which gives a U shaped price path may result if initial reserves are low, giving incentive for high exploratory effort.

Exploration may thus help to explain the observed difference between Hotelling's price path rule, and observed past price paths. Swierzbinski and Mendelsohn (1989) introduce a model that allows explicit description of the effects of information on resource owners' expectations. This allows them to conclude that the forecasted mean rate of change in resource prices is given by Hotelling's deterministic rule, while the observed rate of change differs from this due to the arrival of

information which changes expectations. Their model thus predicts that Hotelling's rule is appropriate for describing how resource owners forecast the value of their stocks, but not for predicting actual changes in price.

The introduction of exploration into the decision problem also has other effects. Fulton and Just (1989) suggest that the existence of two control variables in the depletion problem after exploration is included may allow firms to circumvent government controls more easily, specifically, under certain circumstances anti-trust policy may have perverse effects. This suggests that the policy decisions of government must allow for the extra control variable in order to achieve their stated goals. We will see in the next section how the introduction of mineral processing can have a similar result, in that it too adds another control variable to the problem.

2.3 Introducing Government

Rents and royalties, the effect of various tax structures on optimal extraction together with market imperfections.

The mineral wealth of a nation, it is argued, belongs to all the people of that nation. It is thus argued that the rents that accrue from the extraction of minerals should be used for the benefit of all the people of the state, present and future (i.e. the sustainable development argument). This provides the state with an ideal reason to tax the mineral extracting industry, however, it is not the only one. Taxes may also be used to influence the extraction profile of minerals in order to attain some other policy objectives such as speeding up or slowing down extraction, compensating for externalities or even encouraging exploration or processing of ore. This implies that a government may not always be aiming at a non-distortionary tax that only captures rents. In order to achieve these goals, there is a need to understand what the distortionary effects of taxes are, and if possible to estimate the magnitudes of these effects.

A large number of taxes have been studied in the literature, but only a few really dominate. These are; the severance tax, per unit tax, *ad valorem* severance tax, property tax, profits tax and depletion allowances. A severance tax is a tax on the ore removed from the ground. It can take the form of a fixed payment per unit of metal output (this makes grade selection important), a fixed payment per unit of ore extracted or a proportion of the metal price (also often called a royalty). These are the first three taxes mentioned above, while the profits tax is a payment of some

proportion of profits from the sale of output. The property tax is a proportional tax on the value of the land the mineral reserves are under.

Most of the literature approaches the problem from the position that ore is not processed prior to sale, and while this simplifies the analysis¹¹ it has been shown by Slade (1984 and 1986) that when extracted ore is processed prior to sale, its taxation has (in some cases) a different effect to that when it is taxed in an unprocessed form.

When the ore is not processed, and the firm is in equilibrium prior to the imposition of any taxation, then, “*Pre and after-tax extraction patterns will be the same if and only if the present value of the tax on the marginal unit of ore extracted is equal in all periods.*” Slade (1986) If the present value of the tax on the marginal unit falls (rises), i.e. the tax on the marginal unit appreciates slower (faster) than the interest rate, then the resource owner has an incentive to delay (speed up) extraction. The rule can thus be written as :

$$\begin{array}{ll}
 < r & \text{extraction is delayed} \\
 \\
 \frac{T}{T} & = r \quad \text{the tax is neutral} \\
 \\
 > r & \text{extraction is accelerated.}
 \end{array}$$

Where T is the tax per unit of ore mined, which varies with time and not extraction, and r is the constant interest rate. (Slade '86)

This rule is used by Dasgupta and Heal (1979), Conrad and Hool (1981) and Heaps (1984) amongst others. While Dasgupta and Heal assume an homogeneous ore quality, Conrad and Hool, and Heaps do not make this assumption. The results from Conrad and Hool will be described here, with a mention of some differing results from Heaps(1984), and later from Krautkraemer (1988).

Conrad and Hool (1981) analyse the impact of various tax policies on the extraction profiles of heterogeneous bodies of ore. The types of taxes considered are given in the table below. It is assumed that the tax cannot change the price faced by the extracting firm, so the firm is modelled as a price taker. Further, the ore is assumed to be heterogeneous with two grades being modelled.

¹¹ This goes back to Hotelling who approached the problem from the point of view that the ore body is part of a portfolio of assets, and did not look at the price of pure metal in the market.

This strengthens the assumption of endogenously determined reserves. Thus taxes may induce a mine to extract only high quality ore and leave low quality ore in the ground, where it accrues no rent.

The grading profile derived in the absence of taxes corresponds to the profile of discounted prices, with the highest grades taken when discounted prices are highest, and lower grades taken “sequentially in like manner until further extraction is no longer profitable.” (Conrad and Hool ‘81 p 20) This implies a cut-off grade below which it is not profitable to extract. If prices are not assumed to rise monotonically, then the cut off grade may be extracted prior to higher grade ores, so in general it cannot be said that the mine closes once the cut off grade ore has been extracted. In order to simplify their analysis, Conrad and Hool assume a price path that guarantees that high grade ore is extracted first in the absence of taxes¹². The results given below would change if this assumption were changed.

Heaps (1984) offers some additional results, the basic one being that: taxes increase extraction rates, reduce cut off time and increase the cut off grade. There are exceptions to this result, these being: a profit tax that decreases over time, a progressive tax rate and some royalty policies. These taxes have the opposite effect. These differences from the regular results are due to different transversality conditions, i.e. mining stops due to exhaustion vs. mining stops due to it being uneconomic to continue. (The latter is assumed by Heaps.) Another difference is found in the case of a property tax case compared to Conrad and Hool (1981). The difference is that Conrad and Hool find that a property tax increases cumulative extraction, while Heaps obtains the opposite result. This discrepancy is due to Conrad and Hool’s assumption of fixed lifespan of operation as opposed to the possibility of a shortened lifespan assumed in Heaps’s paper.

Krautkraemer (1988) studies the effects of tax on ore grade selection in some depth. The major result that he derives is that in the presence of heterogeneous ore grades, the usual result of a conservation effect due to a severance tax is diminished and often reversed. A tax induced reduction in total recovery becomes more serious as low grade ore is not recovered even if the tax is removed at a later date.

¹² This would be the norm under Hotelling’s assumptions.

The following table is a summary of results presented in Conrad and Hool(1981 p. 31):

<u>Tax</u>	<u>Grade selection profile</u> ¹³	<u>Reserves (High-grading effects)</u> ¹⁴	<u>Extraction profile</u>
Per unit severance on output	Present to future	Decreased	Present to future
Per unit severance on ore	None	Decreased	Present to future
Ad Valorum severance	None	Decreased	Depends on path of discounted prices
Profits tax with cost depletion ¹⁵	Future to present	Increased	Future to present
Profits tax with percentage depletion ¹⁶	None	Increased	Depends on path of discounted prices
Property tax	Future to present	Increased	Future to present

While many have studied the theoretical effects of a tax on extraction profiles, with the directions of bias being derived, there has not been a major attempt to calculate the relative sizes of these biases. An exception is the efforts of Gamponia and Mendelsohn (1985). These writers study the relative efficiency and equity of unit, yield, property, and windfall profits taxes applied to non-renewable resources. A partial equilibrium simulation model is solved in order to compare the effects of each of these taxes, which are then compared on the basis of the size of the welfare loss in which each results. The equity of distribution of the welfare effects between producers and consumers is also analysed. The Results of their analysis were as follows: -

- A yield tax was found to be most efficient, unless the base price of a windfall profits tax is set close to the extraction costs.
- Unit and property taxes are the least efficient.

¹³ This refers to how the tax affects when the highest grade ore is extracted.

¹⁴ This refers to how the cut-off grade is affected by the tax, thus reserves decrease for the first tax as the cut-off grade is increased.

¹⁵ Cost depletion is defined in Conrad and Hool (1981) as a fixed allowance per ton of final output produced.

¹⁶ Percentage depletion is defined as a fixed proportion of the current value of output.

- All taxes fall primarily on the owners, with the burden of property and windfall profits taxes on producers exceeding 100 percent. This implies that these types of taxes can even make consumers better off.

Some other interesting results in this field of study that are relevant to this paper are due to Livernois (1991), Kolstad and Wolak (1983), Campbell and Lindner (1985) and Slade (1984 and 1986). John Livernois offers some insight into the effects of tax brackets on extraction profiles. Tax brackets are used as an apparently innocuous way of approximating a non-linear tax system. Livernois found that these tax brackets have unexpected dynamic effects on the extraction profile. Specifically, he found that tax brackets in profits and severance tax systems result in periods where extraction rates are held constant. This is in contrast to the expected monotonically declining extraction path.

The results of Kolstad and Wolak are of particular relevance to South Africa¹⁷. They study the effects of interregional competition for taxes, and find that this kind of competition can greatly reduce the amount of rent that can be extracted in comparison to the rents extractable by a cartel. They conclude however, that the reduction is not sufficiently large to imply that a cartel is necessary.

Earlier in this chapter the effects of exploration on the extraction path were noted. Campbell and Lindner (85) offer some insights into the effects of taxation on exploration by the firm. The results from their work can be summarised in the following set of propositions:¹⁸

1. If the firm is risk neutral then the imposition of simple form of resource rent tax leaves exploration effort unchanged provided the exploration costs are fully offset against taxable income. On the other hand, if exploration costs can only be partially offset against taxable income, the effect of the resource rent tax will be to reduce exploration of deposits that are expected *a priori* to be profitable;
2. in the absence of a resource tax the more risk averse the firm is, *ceteris paribus*, the more effort it will devote to exploring 'promising' deposits and less to 'unpromising' ones;

¹⁷ The level of relevance will be determined by the powers allocated to the provinces in the new constitution. If we move towards a greater degree of federacy, then the provinces may have greater power in determining province specific mineral taxes. This is when a degree of competitiveness may develop.

¹⁸ Campbell and Lindner (1985) p. 159.

3. in the case of the risk averse firm, the higher the rate of resource rent tax with full loss offset, the less effort the firm will devote to exploring 'promising' deposits and the more to 'unpromising' ones.

As mentioned above, most of the literature approaches resource taxation with the assumption that the tax falls directly on the unprocessed ore. Slade (1984 & 1986) approaches the problem from the perspective that the ore is processed to some degree after extraction and prior to sale. There are thus other inputs into the extraction and processing cost functions besides ore. The model presented by Slade (1984) is less restrictive than most in that it allows for less restrictive extraction and processing technology, depletion effects (costs increase with cumulative extraction), less than complete depletion of the ore body (cut off grades), multiple grades and multiple outputs (by-products and coproducts)¹⁹. She found that when ore is combined with other inputs in the processing stage, the effects of taxes and subsidies is to change the extraction rates and processing intensities in opposite ways. Thus for example she finds that the imposition of a royalty causes both cumulative ore extraction and the intensity of processing to fall, leading to a greater decrease in metal output than ore extraction. A severance tax on the other hand causes cumulative extraction to fall while processing intensity rises. Metal output thus falls by a smaller amount than ore extraction (this because ore has become relatively more expensive than other inputs).

In her 1986 paper, Slade introduces a methodology for finding the effect of taxes on ore extraction when these taxes are levied at various stages of production. The model she uses assumes a vertically integrated firm which extracts and refines ore and sells metal. In this situation, a tax policy is said to be *absolutely* neutral if it does not affect the extraction rate of ore, the marginal rate of technical substitution between ore and the other inputs into the production process and the rate of output of metal. A tax policy is said to be *relatively* neutral if it leaves the extraction rate unchanged.

¹⁹ Although Slade's model allows for a much greater degree of certainty concerning the effects of the imposition of a tax than earlier models, it will not be used to evaluate tax policies later in this paper. The reason for this is that the tax on most of the South African mines is a neutral, flat rate profits tax, and where there is proposed change it is in favour of a formula tax system such as the one presently used for gold mines in South Africa. The effects of this formula tax are quite well understood and as such it is felt that it is not necessary to use a new model to evaluate it.

The effects of taxes which are levied downstream on metal production or metal revenues must be traced backwards in order to find equivalent taxes on extraction. Slade thus finds mappings to translate downstream taxes into direct taxes on ore. The study is limited to cases for which the tax is independent of the extraction rate, as taxes which depend on the extraction rate give producers an incentive to alter extraction rates to lower their tax burden and thus can not be neutral.

The analysis is extended to consider the effects of taxes upon extraction when levied on firms using different production technologies, and the derivation of a method for deriving tax policies that achieve specific goals such as neutrality, conservation or increased depletion. While it is possible to design a tax that is neutral for an industry, it will not be neutral for every firm unless each firm uses identical technology. Slade also notes that in order to avoid counter intuitive effects, it would be beneficial to levy the tax on a stage of production that is as close to extraction as possible. Unfortunately the details of this work are beyond the scope of this paper, and the interested reader is thus referred to Slade (1986) for the details of the analysis.

Before moving on to the next chapter which details some of the real world tax experiences, it is of some great interest to note a case described by Dore (1987). Dore's paper highlights a point that is not given much attention in the literature, and that is the ability of monopoly or highly concentrated producers to influence the tax policy that they face. In the case described by Dore, the world bauxite producer oligopoly effectively reallocated production in response to Jamaican resource rent taxation. The oligopoly introduced a successful strategy of exploration and time phasing of bauxite production world wide which allowed them to avoid the high tax policy of the Caribbean members of the International Bauxite Association. Bauxite production in Jamaica was reduced in favour of production in Australia, Guinea and Brazil. The effect on Jamaica has been to reduce per capita income to such an extent that in 1980 per capita income was 25 percent below what it had been in 1972.

While the kind of concentrated producer power that prevails in this sector is not common, the power of concentrated producers to influence tax policy, or to reallocate production to avoid taxes should not be ignored, and deserves further study.²⁰

²⁰ See appendix B for a brief discussion of concentration in South African mining.

3. Real world tax examples

3.1 South Africa

3.1.1 Minerals background

South Africa is endowed with exceptional mineral resource reserves, and has been described as a country of “geological superlatives”. These resources are mainly concentrated in only six geological units, namely:

- 1) The Witwatersrand (2.6-2.9 Ga): gold and uranium
- 2) The Bushveld Igneous Complex (BIC) (2.1 Ga): platinum group metals (Pt, Pd, Rh, Ru, Ir, Os), chromium, vanadium, iron and titanium (not produced).
- 3) The Transvaal (Griqualand West) (2.4 Ga): manganese and iron.
- 4) The Karoo (0.18-0.25 Ga): coal and uranium (not mined)
- 5) Kimberlite pipes (intrusive, various ages): diamonds
- 6) Coastal Sands (recent): titanium, pig iron, zircon and silica.

In general the mineral potential has been realised and mineral production reflects mineral reserves. By far the most important mineral in terms of value is gold. This is followed by coal, platinum, diamonds, iron ore and copper. However many of these minerals are beneficiated before export in which case the order would be gold, iron and steel, PGMs (and by-products), coal and ferro-alloys. In terms of global output the minerals for which South Africa’s share is greater than one-fifth are: platinum (67%), rhodium (63%), vanadium (50%), chromium (38%), palladium (31%), gold (28%) and titanium (22%).^{21 22}

The following table shows South Africa’s position in terms of world mineral reserves. As is evident from the table, South Africa has the world’s largest reserves for six major minerals, namely, manganese, the platinum group metals (PGMs), chromium, vanadium, gold and alumino-silicates. In addition, South Africa has substantial reserves of many other minerals such as iron ore, coal and base metals.

²¹ ANC Minerals and Energy Policy Workshop : Draft Mineral and Energy Policy, Discussion Document, November 1994

²² Further statistics on South African production, exports and reserves, see Appendix C.

South Africa: ROLE IN WORLD MINERAL RESERVES²³

	SA Reserve Base as % of World 30/6/91	Rank
Manganese	82	1
PGM	69	1
Chromium	54	1
Gold	40	1
Alumino-alicates	37	1
Vanadium	33	1
Zirconium	14	2
Fluorspar	10	4
Coal	9	5
Nickel	9	5
Titanium	8	5
Phosphate rock	7	3
Iron	6	7
Zinc	5	4
Lead	4	6
Antimony	3	6
Vermiculite	na	2
Uranium	na	6
Asbestos	na	4
Diamonds	na	4

3.1.2 Taxation of South African Mines²⁴

The mining income of a company (not an individual) is taxed differently to other income. The system is full of anomalies as different minerals are treated differently, however, despite these

²³ Source:- Chamber of Mines

²⁴ Adapted from The Margot Commission of Inquiry into the Tax Structure of South Africa. This section offers a description of the major tax principles affecting the South African mining industry in the recent past and present.

complexities, there are some general principles that are universal to the mining industry, and these are described below, followed by a description of some of the tax rules for different minerals.

3.1.2.1 Mining Leases

Prior to 1991, all rights to mine precious stones and precious metals were vested in the state and a lease was required to mine such minerals. The state share of profits that was payable in respect of the lease was calculated on a sliding scale of the same form as the gold tax formula. As the form and thus the effects of the gold tax formula and the lease formula were the same, only the gold formula will be discussed. All lease payments of this form ended in 1993.

The rights to mine all minerals other than precious stones and precious metals were vested in the holder of the mineral rights to the land in question. If the land was privately held, then these rights were normally held by the owner of the land, if state land was in question, the mineral rights belonged to the state.

Since 1991, the right to mine any mineral has been vested in the owner of the mineral rights, i.e. the state no longer reserves the right to mine precious stones and precious metals.

3.1.2.2 Redemption of Capital Expenditure

The redemption allowance referred to here is the deduction of capital expenditure from revenue before tax. Capital expenditure is thus expensed or written off. The redemption allowance was granted for both tax and lease purposes. Before ring fencing was introduced, the full amount of capital expenditure could be deducted in a single year.

Redeemable capital includes:

- capital expenditure on shaft sinking

-development, general administrative and management costs (including interest and other charges) incurred prior to the commencing of production, or during any period of non-production²⁵.

The reasons given for the redemption allowance are:-

-Most of the capital spent on mining goes into infrastructure to facilitate mining, this capital has no residual value

-Assets such as surface plant are generally wasting assets, in terms of the fact that the ore body has a limited life

-The long lag between the start of capital investment and the generating of returns from that capital

-The risk profile of mining means that development is dependent on risk capital

-This risk capital is in the form of shareholdings, which have no value after termination of mining operations

-The allowance thus serves to reduce investor risk.

Ring fencing was introduced in 1984 to prevent capital expenditure being deducted from income other than from mining, and was later extended to prevent deductions from income other than from the specific mine the capital was invested in. Any excess could be carried over for deduction in following years. Mines could thus not fully expense capital expenditure in a single year. The fences were not impenetrable to normal revenue losses. The fences were initially erected in order to prevent the erosion of the tax base, however, they are being removed (the industry is making a strong case for their complete removal), and there is now a 25% breach of the fence permissible in certain circumstances.

The reasons given for the removal of the fences are:

- To allow capital to move freely to its most efficient use, and not to where it does the most good in reducing the investor's tax burden;

²⁵ There is no redemption allowance for the purchase of land or mineral rights.

- To give credit for the riskiness of the investment in mines
- The immediate write-off of capital is simpler to administer
- A write-off over the life of the mine would involve contentious estimates of life span.

3.1.2.3 Capital Allowance

Capital redemption is a write-off of actual capital expenditure, while the capital allowance is a *notional* addition to such expenditure, i.e. mines were effectively allowed to recover capital and interest. The system allows for an annual inflation of the initial capital investment until such time as the mine is generating enough profit to redeem such capital. The capital allowance was introduced in the 1950's to encourage the development of deep level gold mining, and is currently exclusive to the gold mining industry.

The effect of the capital allowance and the redemption allowance is to lower the price of capital invested in mining. Due to these tax breaks, investment can be financed at interest rates far below market rates, and with high inflation rates, it is likely that they face negative real rates of interest. This of course has a bearing on the discussion on interest rates given in appendix A, where it is suggested that if mines use the market rate of interest in their investment and extraction decisions and the market rate of interest is higher than the social rate, then the increased extraction rate induced by the higher rate may be offset by the reduced investment in mining due to the same higher rate. If the Government puts a wedge between the rate used for investment decisions and the rate used for extraction decisions, specifically, if the former is lowered by the tax system as is the case in South Africa, then there will be **excess investment** and **faster extraction**. These two effects obviously result in a tendency towards extraction of the resources being too fast when compared to our benchmark for social welfare. In the absence of any other force (such as monopoly power) to slow down extraction, the result would be a definite increase in extraction as compared to the benchmark. This result may be in conflict with the State's policy of lengthening the lifespan of mineral reserves and mining as a whole!

3.1.2.4 Mines Other than Gold and Diamonds

These mines pay a (neutral) flat rate companies tax of 40%, plus 15% on distributed profits, giving an effective rate of 47.83% on profits that are distributed. This dual tax system was introduced in an attempt to encourage mines to re-invest their profits. The success of this dual tax is however debatable, since mines traditionally pay out all or most of their profits.

3.1.2.5 Diamond Mines

Diamond mine income was taxed at a (neutral) flat rate of 40% with a 25% surcharge, giving an effective rate of 56.25%. This has changed to a flat rate of 40% plus 15% on distributed profits as for other minerals. In addition there is an export duty of 15% on the value of exported unpolished stones. This duty is tax deductible, and generates more revenue than the company tax on diamond mining enterprises. The duty is purported to be a protective one, in place to encourage the domestic diamond cutting and polishing industry.

3.1.2.6 Gold Mines

Probably the most striking feature of the South African mining tax system is the gold mine tax formula, and most of the attention of this chapter will thus be focused on it. The formula dates back (not in an unbroken line) to the Mining Taxation Act 6 of 1910, and taxes mines on a sliding scale, introducing an element of cross-subsidisation to the tax system, with the state taking a larger share of profits from richer mines, and a smaller share from poorer mines. The reason the formula was introduced, was to encourage mines to work lower average grades of ore than they would otherwise do in the absence of the tax, and thus extend the working lives of the mines. What the formula in effect does is to pay the producers to deliberately make a loss by mining ore of a lower grade than would be mined in absence of the tax. This is because the loss made on mining this low grade ore is more than offset by resultant the tax savings. The mines make the profits cake smaller so as to have a bigger slice than they had before, at the expense of the fisc.²⁶ The formula allows the mines to make a moderate but predictable return on their capital, and taxes away the rest. Obviously this is an attempt to extract the rents from gold mining, but is far from neutral and even

²⁶ A numerical description of this phenomenon is presented in Appendix D.

reduces the amount of the rent. The fisc thus sacrifices some of the rent in order to extend the life of the mines.

The formula is of the form:

$$\begin{aligned} T &= \% \text{ of gold profits that goes to government} \\ &= A - AB/X \end{aligned}$$

Where A is a constant (60) and B is one of two constants depending on the age of the mine. (The value of B determines the maximum amount of profit as a percentage of gross revenue which a mine can earn before paying tax.) There are thus two primary versions of the formula, one for pre-1966 (B=6) mines, and one for post-1966 (B=8) mines. These are also referred to as the "360 formula mines" and the "480 formula mines" respectively. X is the ratio (expressed as a percentage) of profits to revenue.

Since March of 1993, gold mines were given the option of staying with the present tax system, or moving to a new system with lower tax rates on non-mining income, a more favourable formula, but including a 15% dividends tax. Given that a high proportion of pre-tax profits are paid out as dividends, it is unlikely that the mines will change from the old system. Natrass (1995)

Since earnings are equal to average grade milled times tons of ore milled times the price received for output ($E = \text{Average grade} \times \text{Tons ore milled} \times P$), and the cost of processing a ton of ore is generally independent of its grade, the mines can set their earnings by choosing the grade of ore to mine²⁷. This lead to the inverse relationship between the gold price and the grade of ore mined.²⁸ As can be seen from the table below however, this relationship did not hold well during the 1980's, probably due to the fluctuating gold price and the limited ability of mine managers to switch mining activities between ore bodies of different grades. Despite the fluctuations in the real rand gold price, ore grades fell steadily until 1989. Only after 1989 did ore grades begin to rise. Natrass (1995)

²⁷ Or they can mine ore at a greater depth, as this will raise the cost of mining the ore, which has the same effect as mining a lower grade. (See Appendix D for more detail.)

²⁸ Moll (1992) p. 188

Real Rand Gold Price, Working Costs, Profits and Taxation²⁹

<u>Gold mines belonging to the Chamber of Mines</u>							
R1000 in 1990 prices							
Year Ended 31/3	Index of real Rand gold price	Working revenue per ton of ore milled	Working costs per ton of ore milled	Working profit per ton of ore milled	Grade grams per ton of ore	Dividends as % of pre-tax profit	Gold tax as % of total tax revenue
1981	137	325.2	142.5	182.6	6.92	34.4	26.4
1982	122	275	140.4	135	6.76	30.5	14.3
1983	126	273.3	137.3	136	6.55	32.4	9.3
1984	126	265.4	139.6	125.8	6.44	29.8	10.8
1985	145	283.5	140.1	143.6	6.09	29.8	8.1
1986	146	271.3	137.8	133.5	5.63	30.6	10.2
1987	136	237.3	140.4	96.9	5.28	32.5	9.1
1988	131	224.5	140.2	84.5	5.13	31.8	7
1989	115	184.4	133.5	50.9	4.99	39.1	4.5
1990	100	163.5	130.3	33.2	5.05	39.4	2.2
1991	87	148.4	118	30.4	5.2	34.4	1.2
1992	77	136.1	109.9	26.2	5.37	38.5	1
1993	81	160	118.8	41.2	5.56	35.2	0.7

Where the real gold price and the grade are inversely related, there is the possibility of a downward sloping supply curve for gold in South Africa. This is because with a lower grade being mined, the mine would have to mill a greater volume of ore to produce a constant amount of gold. To the extent that the ability to increase the tonnage milled is limited, there is a likelihood that the tonnage

²⁹ Natrass (1995) pp. 858 & 859

could not be increased enough to compensate for the lower ore grade. An indication of the effects of different ore grades on gold output is given by the following table³⁰. (Statistics are for four marginal mines in the Randgold group for the quarters ended June 1995 and March 1995.)

Randgold June Quarter	Tons Milled 000s	Yield g/ton	Gold Produced kg	Cost per ton R	Costs per kg R	Price Received R/kg	Net Profit R000s	Profit after CAPEX R000s	EPS after CAPEX cents
ERPM									
June	241	6.71	1618	324.31	48306	45461	3255	-11875	-7
March	257	5.86	1505	394.37	50267	44001	-410	-10745	-7.7
Blyvooruitzicht									
June	137	6.31	864	274.84	43580	44994	982	-562	-2.3
March	125	6.3	788	285.86	51389	45317	-3851	-5322	-22.1
Harmony									
June	1405	3.48	4892	152.13	43693	45681	15842	984	3.4
March	1470	3.2	4702	139.32	43530	43054	5613	-9293	-32.6
Durban Deep									
June	63	3.75	236	191.32	51107	45157	-1221	-96	-4.1
March	63	4.29	270	185.12	43195	43195	93	-1422	-61.8

As can be seen in the cases of the ERPM and Harmony mines, with the higher ore grades being mined, more gold is produced despite a lower tonnage of ore being milled. This gives some indication of the kind of effect that can be obtained by changing ore grades. Thus, unless the tons of ore milled increases (falls) by the same percentage as average ore grade falls (rises), gold supply moves in the opposite direction to real gold prices: as a result, if the gold price goes up, the share of gold in nominal GDP may rise as the value of gold mined rises, while its share of actual output in the economy falls as there is less gold actually produced! Moll (1992)

At present, South African gold mines are struggling for survival as costs of production rise and the gold price fails to strengthen. In the past these pressures on profitability have been dealt with by merging mines, concentrating on higher ore grades, continuous working (this method is being seriously hampered by public holidays, with JCI estimating that 16 - 18 working days are lost due to these holidays) and decentralisation of management. Each of these strategies is limited, and the mines will have to find new ways of lowering costs and lowering the payable ore grade if they wish to continue operating. Previously the incentive to lower costs was reduced by the tax system, and now the price for that lowered incentive is being paid.

³⁰ Urquart (1995)

3.1.3 Comments

The current flat rate profits taxes on minerals other than gold are neutral in that they do not alter the profile of discounted returns, i.e. they do not give the mine owners any incentive to change their extraction profiles from the one they would choose if the tax were absent. The case of gold is however much different, with the formula tax altering the grade selection profile as well as the extraction profile, and (in theory) extending the life of the mine. “In theory” because in reality there is no guarantee that prices will continue to rise faster than costs and that the expected life span of the mine will be realised.

4. Minerals policy in The New South Africa

The ANC has no definite minerals policy, its last statement on the minerals issue was a draft document for the ANC Minerals and Energy Policy Workshop in November of 1994, and was labelled “for discussion”. It is this document, and some of the more definite policy statements which will be referred to in this section.

4.1 First a look at general ANC policy as it pertains to minerals

4.1.1 Environmental Policy³¹

The ANC believes that all citizens of South Africa, present and future, have the right to a safe and healthy environment, and to a life of well-being. The broad objective of our environmental policy will be to fulfil this right. In this context, growth and development within South Africa will be based on the principles of sustainability.

2. Guiding Principles

The ANC subscribes to the following principles:

- 2.1 the principle of sustainable development;
- 2.2 equitable access to resources;
- 2.3 public participation in planning, development and management of resources;
- 2.4 an integrated approach to environmental issues that relates to all sectors of society;
- 2.5 public right of access to information and the courts on issues of environmental concern.

3. Objectives

3.1 Adequate protection, conservation and restoration of resources, based on the following:

- 3.1.3 The sustainable utilisation of renewable resources.
- 3.1.4 The rational utilisation of non-renewable resources.

³¹ The whole of section 4.1.1 consists of quoted sections from the ANC Policy Guidelines, F. The Environment. Only sections directly relevant to the minerals sector are quoted.

4. Functional Priorities

Bearing in mind the national development priorities (namely employment creation, housing, food security, rural and urban development, macro-economic balances, peace and stability), the ANC's environmental programme will initially focus on:

- 4.5 The introduction of measures and campaigns intended to curb pollution generated by agriculture, mining, industry and any other activities;
- 4.6 The introduction of measures to counter the privatisation or removal of public rights to common natural resources such as forests, the coastline, water, mountains and wildlife resources;
- 4.7 The establishment of an inventory of our natural resources;

4.1.2 Minerals Policy³²

In order to promote, support and regulate minerals and mining it is essential that government institutions are competent and efficient. Exploration and mining are high risk businesses and consequently it is important that individuals and companies are confident in their dealings with state institutions and that decisions are made timeously and efficiently. If contracts are to be negotiated and investment mobilised it will be important that institutions respond rapidly and professionally.

In South Africa there has been significant white private sector involvement in the minerals and mining sector. Consequently the mining ministry has tended to take a back seat to the much more influential industries represented for example by finance and trade. Equally the functions of this ministry have become one of policing and regulating the industry and there has been little emphasis on promotion of minerals and mining. As a result government departments, and statutory bodies have tended to be looked upon as unhelpful bureaucrats who frequently became obstacles to ongoing and effective policy reform and new commercial endeavour. The private mining companies also played the role of promoters and salesmen for the industry, and although much good was done and South Africa has a highly developed large scale mining industry, very often the needs of individuals and communities, and the state were overlooked or ignored.

³² Sections 4.1.2 and 4.2 consist of quoted sections of the ANC Minerals and Energy Policy Workshop Draft Mineral and Energy Policy, Discussion Document of November 1994. All the quoted material is presented in italics

The country is relatively well explored and it is unlikely that new major deposits will be found. While iron ore, coal, the platinum group metals and chromite have a long term future, the gold mining and diamond mining industries are mature and will decline in the longer term. As these two minerals represent about two-thirds of total value, employment and contribution to the balance of payments and other aspects of the economy, this presents a major economic and political problem for the future. Awareness of this problem and farsighted planning around the downscaling of the industry is essential. The priorities facing the industry include:

- *management of the downscaling of the industry in terms of employment;*
- *the extension of the life of what mineral resources remain;*
- *the discovery of new resources through investment in exploration;*
- *the exploitation of known, but unexploited, mineral deposits;*
- *increased focus on the optimisation of mineral exploitation;*
- *increased incentives to add value to minerals prior to export, and disincentives for exporting unbeneficiated ores.*

ANC mineral policy is centred on the Freedom Charter of 1955 which states that:

“The People shall share in the country’s wealth”, and that

“The mineral wealth beneath the soil ... shall be transferred to the people as a whole.”

This was amplified at the Ready to Govern Conference in 1992 which stated:

“The mineral wealth beneath the soil is the national heritage of all South Africans, including future generations. As a diminishing resource it should be used with due regard to socio-economic needs and environmental conservation. The ANC will, in consultation with unions and employers, introduce a mining strategy which will involve the introduction of a new system of taxation, financing, mineral rights and leasing.

Policies will be developed to integrate the mining industry with other sectors of the economy by encouraging mineral beneficiation and the creation of a world class mining and mineral processing capital goods industry.”

The key policy themes are firstly that minerals in the ground are part of the nation's wealth, that workers and the nation should get their fair share of the wealth generated and that minerals mined are integrated into the rest of the economy through further processing (beneficiation) before export.

The ANC's minerals policy was significantly further developed at the Reconstruction and Development Programme Conference in February 1994, together with the Alliance Partners, which adopted the following 14 policy points:

- 1) South Africa is one of the world's richest countries in terms of minerals. Up to now, however, this enormous wealth has only been used for the benefit of the tiny white minority.*
- 2) The minerals in the ground belong to all South Africans, including future generations. Moreover, the current system of mineral rights prevents the optimal development of mining and the appropriate use of urban land. We seek the return of private mineral rights to the democratic government, in line with the rest of the world. This must be done in full consultation with all stakeholders.*
- 3) Our principal objective is to transform mining and mineral-processing industries to serve all of our people. We can achieve this goal through a variety of government interventions, incentives and disincentives. Estimates suggest that the establishment of a government minerals marketing auditors' office and the national marketing of certain minerals would enable South Africa to realise greater foreign-exchange earnings. The management and marketing of our minerals exports must be examined together with employers, unions and the government to ensure maximum benefits for our country.*
- 4) Minerals and mineral products are our most important source of foreign exchange and the success of our RDP will in part depend on the ability of this sector to expand exports to avoid balance of payments constraints in the short to medium term.*
- 5) Mining and minerals products contribute three-quarters of our exports and the industry employs three-quarters of a million workers, but this could be much higher if our raw materials were processed into intermediate and finished products before export. Our RDP must attempt to increase the level of mineral beneficiation through appropriate incentives and disincentives in order to increase employment and add in value to our natural resources before export. Moreover, this policy should provide more appropriate inputs for manufacturing in South Africa.*

- 6) *Minerals are a vital input for numerous mineral-based industries. These industries, however, have difficulty in becoming internationally competitive due to the fact that the refining companies usually set higher prices for the domestic market than their export prices, a practice known as import parity pricing. A democratic government must consider mechanisms to encourage companies to sell to local industries at prices that will enhance their international competitiveness.*
- 7) *Existing tripartite structures such as the Mining Summit must be strengthened in order to facilitate national development strategies for the mining and mineral-processing industry.*
- 8) *Democratisation of the mining sector must involve new laws to build workplace democracy for miners by requiring employers to negotiate the organisation of work with their employees and their unions. Programmes must be established to allow financial participation by workers in mining companies in a meaningful way (including measures to influence the policies of financial institutions, especially insurance companies and pension funds, which hold significant stakes in the mining sector and in which our people have substantial investments). And anti-trust legislation and other measures must be implemented to permit the monitoring and appropriate control of mining, mineral processing and marketing.*
- 9) *International demand and supply patterns for metals and minerals have undergone fundamental changes in recent years that necessitate the restructuring of this major industry. In the medium term, this probably means a continued decline in the number of people employed in the mines. Up to now, the heaviest burdens associated with down-scaling have been borne by miners, one third of whom have been retrenched. The RDP must put into place mechanisms to ensure orderly down-scaling of our mines so as to minimise the suffering of workers and their families. Measures should include the reskilling and training of workers for other forms of employment.*
- 10) *Mining is a hard and dangerous job, and mineworkers labour under stressful conditions, often deep under the earth. The RDP envisages a new set of minimum standards for the mining industry that ensure fair wages and employment conditions for all workers and a health and safety system that recognises the special hazards related to mining.*
- 11) *Most mineworkers are forced to live in single-sex hostels and remit part their salaries. In future all workers must have the right to live at or near their place of work in decent accommodation and shall have full control over their after-tax salaries. In addition, the*

mining companies must take some responsibility for the education, training and social needs of miners and their families as an integral part of labour policy on the mines.

- 12) Mining can be extremely destructive of our natural environment. Our policy is to make the companies that reap the profits from mining responsible for all environmental damage. Existing legislation must be strengthened to ensure that our environment is protected. Before a new mine can be established there must be a comprehensive environmental impact study.*
- 13) The Southern African region also has enormous mineral resources that have not been mined, due in part to the destabilisation policies pursued by the apartheid state in the last twenty years. In the spirit of mutual co-operation, the RDP should extend across our borders by using our considerable expertise in mineral exploration and exploitation to rehabilitate and develop the mineral potential of our neighbours. In this regard a special facility should be created to promote investment in the sub-continent.*
- 14) The government must consider ways and means to encourage small-scale mining and enhance opportunities for participation by our people through support, including financial and technical aid and access to mineral rights. However, standards in respect of the environment, health, and safety and other working conditions must be maintained.*

4.2 Description of proposed minerals policy

4.2.1 Draft Environmental Policy for the Minerals Industry

INTRODUCTION

The issue of environmental management in the industry is at present largely neglected. Mines are by nature damaging to the environment, and until recently there has been little effective control over environmental management on mines. The Minerals Act of 1991 introduced, for the first time, law on environmental regulation and rehabilitation. The problems faced by the State in the management of mines which closed down prior to the promulgation of this Act, primarily the old coal and deep level gold mines, is sufficient motivation in itself to ensure that mines take responsibility for their own environmental management during the operation of the mine, and ensure that the property has been rehabilitated to the extent that it does not pose a threat to the physical environment and the community on closure.

The ANC's policy on environmental management, as expressed in it's document "An introduction to ANC Environmental Policy", states that the ANC believes that all citizens,

present and future, have the right to a life of well being. Any environmental policy for the minerals industry must incorporate this fundamental philosophy.

ISSUES FOR CONSIDERATION

- The balance between encouraging development and maintaining high standards of environmental management;*
- potentially cross-cutting environmental legislation and regulation introduced by different State department's and private members motions;*
- the management of environmental damage caused by small-scale mines;*
- the establishment and administration of rehabilitation funds;*
- acid mine drainage from the sulphur-rich gold and coal mines;*
- the cost and administration of the Environmental Management Programme Reports (EMPR's).*
- future trade barriers could be based on the environmental effects of our production methods that do not take into consideration environmental degradation*

POLICY

- 1. Mining can be very destructive to the environment. There must be a balance between the economic benefits of a mine development and the ecological damage caused. The basic principle must be that the mining companies should be responsible for the rehabilitation of a closed down mine site.*
- 2. To introduce State-managed water management schemes in catchment areas affected by acid mine drainage, the costs of which would be met on a pro-rata basis determined by water quantity and quality, as is done for the SIMRAC programme;*
- 3. To provide for broader consultation on mining environmental issues at planning and EMPR stage, particularly with the communities directly affected by the mining;*
- 4. To educate small-scale miners on environmental management as a pre-requisite to being granted mining authorisation;*
- 5. To provide for State management of areas where there is a high spatial concentration of small-scale miners;*

6. *To investigate the feasibility of a one-stop shop for processing mining-related environmental legislation and regulation through the establishment of the DMEA as the lead agent with seconded professionals from the Departments of Environmental Affairs, Water Affairs and Forestry, and Agriculture;*
7. *To create mine-specific trust funds instead of the current format of rehabilitation funds, and to have these funds to cover all aspects of mining impact, managed by boards of trustees which would include all stakeholders, particularly the affected communities;*
8. *To make the funds more affordable by replacing the up-front single sum guarantee by a production related sinking fund based on estimates of costs of rehabilitation at cessation of operations.*
9. *To investigate applying a mining levy, part of which should be used to repair past damage where the perpetrator cannot be identified and future damage that cannot be linked to a specific producer.*
10. *The 'polluter pays' principle should apply to all impacts of mining activities.*
11. *South Africa should endeavour to ensure that the environmental policy complies with international norms for mining.*

4.2.2 Draft Policy on Mining Taxation

INTRODUCTION

Minerals are one part of a country's natural wealth or patrimony for which users must pay rent to the 'people' or state to deplete (mine). The State derives its share of rent from the industry through both the taxation levied on the industry, as well as income from rentals on State-owned mineral rights. Such rentals are in effect what are termed royalties elsewhere in the world where the mineral rights belong to the state. Royalties to compensate the state for the depletion of its mineral wealth are generally calculated on the volume or value (sales) of the mineral mined. In the past South Africa had a lease tax that was imposed to this end but which was scrapped in the new Minerals Act of 1991.

Funding the RDP and other government programmes requires collecting more tax. This can be done by raising tax rates or, preferably, increasing the tax base in the following ways. First, by providing incentives that will stimulate the industry and bring new mines into production. Secondly, by encouraging the return of mineral rights to the State, revenues from rentals for

access to these rights will be increased. Thirdly, by introducing a Minerals Rights Tax which would serve both to increase revenues to the fiscus, as well as encouraging exploration activity and the possibility of new mines.

ISSUES FOR CONSIDERATION

With the exception of gold mines, mines are subject to the same tax regime as other industries. Gold mines are not taxed on a flat rate, as are other mines, but are taxed by means on a tax formula. The tax formula for gold mines was first introduced in 1936 with a view to encouraging the mining of marginal ores at deeper levels by easing the tax burden on the less profitable mines in order to increase the profit to revenue ratios, and hence the return on investment. In doing this it introduced an element of cross-subsidisation from the more profitable mines by increasing the State's share of profits from these mines, while reducing its share from the less profitable mines.

The system of variable taxation linked to profitability has allowed the gold mines to successfully negotiate difficult periods and has given the state a reasonable share of windfall rent and differential rent. In this respect, the formula has been very successful. It is desirable that the extension of formula tax to non-gold mines be investigated as a means for stimulating the industry as well as ensuring its long term survival and for giving the state a fair share of mining rents. The taxation level must be reasonable both to promote international and domestic investments and to ensure that a proper share of the rent goes back to the State.

Mines tend to be capital intensive with very long lead times. Thus the cost of capital is a crucial element in the viability of new projects and should continue to be ameliorated through the current system of immediate write-off in the first year of operation with the balance carried over to the next year, but the effect of inflation on the size of the write-offs needs to be taken into account. As mineral refining and beneficiation projects also have long lead times, this system should be extended to cover their capital expenditure, rather than the old system of giving immediate negotiable tax write-offs (37E) which could severely compromise the fiscus and the RDP.

- 1. Measures to enhance the optimal exploration and exploitation of all mineral resources need to be devised. The current legislation neither defines what is meant by optimal mining, nor has sufficient powers to enforce optimal mining practices. Incentives and*

disincentives need to be built into the tax and royalties regime to encourage optimal mining (at the lowest possible cut-off grades) and the optimal use of South Africa's minerals (through beneficiation before exports). In this regard consideration should be given to the extension of the gold formula tax to other mining and the imposition of a small royalty that decreased depending on the stage of beneficiation before export.

POLICY

- 1. To consider a Mineral Rights Tax on privately held mineral rights that could be offset against any exploration expenditure.*
- 2. To consider the imposition of a small levy on all minerals extracted, based on the tonnage removed (depleted). Such levies should be low so as not to inordinantly raise the investment threshold and should be mineral specific.*
- 3. To consider the application of a small beneficiation related levy on all minerals exported, at a declining rate depending on the degree of beneficiation (zero for the export of metals).*
- 4. To consider the extension formula taxation all mining (not just gold and uranium), but with mineral specific formulas.*
- 5. To reassess ring fencing in order to encourage development of otherwise uneconomic mineral deposits. However, the removal of ring fencing should be qualified and discretionary.*
- 6. To consider the increase of the tax deductible capital at the rate of inflation from the year of expenditure to the year of write-off, to compensate for the effects of inflation on the cost of capital.*
- 7. To extend the gold mining inflated capital write-off system to other mining as well as mineral beneficiation projects (rather than a re-introduction of 37E).*
- 8. To expand the industry tax base by promoting minerals development through encouraging foreign and local investment in exploration and mining by introducing creative minerals tax incentives that could include greater than 100% write-offs and, possibly, flow-through share schemes.*
- 9. The economic and social impact of the above policies should be investigated to ensure that the overall goals of growing the industry's contribution to national well-being are achieved.*

4.2.3 Draft Policy on Mineral Rights

INTRODUCTION

South Africa is amongst the worlds richest countries in terms of mineral wealth. This wealth is a key national heritage and the property of all South Africans. Current mineral rights laws have limited the optimal development of mining and appropriate use of urban land. It is the stated view of the ANC that private mineral rights should be returned to the democratic government, as is the case in the rest of the world, including those countries which have successful mining industries and in which small and large scale mining takes place side by side. Revision of mineral rights laws, and related statutes and institutional support mechanisms, must be done in full consultation with all stakeholders. Prospectors, miners and investors must be confident that their risk finance will not be jeopardised by changes in policy, and equally that the allocation and tenure of mineral rights will be properly managed.

ISSUES FOR CONSIDERATION

Aside from the USA, South Africa and a few exceptions elsewhere for specific minerals, most countries assume public ownership of minerals. The United Nations passed various resolutions on these issues in the 1960's and most African States have adopted the approach of "Permanent Sovereignty" over their mineral resources. Importantly this does not prevent the allocation of secure title to mining rights to private parties, nor does it imply that rights cannot be tradable. It does however establish that the State can charge for access to the resource and that it has a legitimate interest in the manner of its exploration and exploitation.

The international trend over the last forty years has been towards public ownership of mineral rights. This has variously been achieved through the introduction of mineral rights taxes as well as several forms of expropriation.

POLICY

- 1. Security and continuity of tenure for mineral exploration and mining is essential to encourage high-risk exploration and to ensure that companies marshal large sums of money to undertake mining.*
- 2. Investors need to be assured of the right to proceed from exploration to mining provided pre-defined criteria are met.*

3. *Mining licenses must be of sufficient duration to make exploration and development commitments worthwhile.*
4. *The practice of freezing potential mineral wealth in areas of privately owned mineral rights should be discouraged. The imposition of a mineral rights tax, that would be deductible against any exploration expenditure, should be considered. If the private owner of mineral rights abandoned them to the state he/she should have first option on an exploration license over the same area, in exchange for submitting all past exploration data on the property.*
 1. *Access to prospective mineral terrains is key to encouraging mineral exploration. This includes access to minerals beneath the surface (mineral rights) and to the surface to carry out exploration. In order to free up prospective mineral terrains for exploration a mineral rights tax should be considered that would be deductible against any exploration expenditure.*
5. *Where the state is the holder of mineral rights, a system of licenses or rights should be introduced consisting of exploration and mining licenses with defined periods and work commitments, which will ensure a turnover of exploration properties and encourage new investors. The minimum work requirements should be substantially less than the mineral rights tax to encourage the return of privately held rights to the public domain.*
6. *The power to grant mineral licenses should reside with one authority and not be subject to overlapping or concurrent jurisdictions (the lack of clear rules will hinder the orderly development of mining).*
7. *To prevent monopolisation of territory it may be necessary to limit the number of licenses that can be granted to any one company or group of related companies.*
8. *A suitable legal framework for small scale mining may be necessary, such as the creation of special mining zones with a high small scale mining potential.*
 1. *The current mineral rights dispensation in South Africa will have to be changed if small scale mining is to be promoted. The problem of access to mineral rights could be addressed in the short term by direct negotiations with the current holders, and in the medium term by the introduction of a system which will ensure that the mineral rights revert back to the state, such as a tax.*

4.2.4 Draft Policy on Mineral Beneficiation and Domestic Raw

Material Pricing

INTRODUCTION

Mining is a primary industry that exploits a national asset, part of the wealth of present and future generations. Through adding value or beneficiating mineral resources a country can maximise the economic rent it derives from the asset, develop its economy and stimulate economic growth from its mineral sectors. The export of unbeneficiated ores is often sub-optimal use of a wasting national asset.

A considerable amount of South Africa's mineral resources are exported as raw ores or only partially processed. South Africa has steadily improved its ratio of beneficiated to primary products exported since the 1970s, but these ratios are still well below the potential suggested by the quality and quantity of its mineral resources.

South Africa has the potential to raise the proportion of mineral output that becomes beneficiated by virtue of its large reserves, major transport advantage accruing to beneficiating close to the resource source, local skills base in engineering and related areas and most crucially, low energy costs. A number of constraints on further beneficiation efforts do exist in the form of the large scale capital requirements needed by most projects, distance to final markets for much of the output from local plants, the high cost of intermediate inputs and skills shortages in certain technical and managerial categories. The countries experience of large scale beneficiation projects has tended to be export oriented. While this has had a positive impact on export earnings, down stream value adding fabrication industries have been neglected.

Beneficiation involves processing a natural resource to transform it into a higher value product, usually an intermediate product used as an input by fabricators. Fabrication involves the production of final goods by transforming intermediate inputs, i.e. beneficiators supply inputs to fabricators to make final goods.

POLICIES TO PROMOTE BENEFICIATION

- 1. The local fabricator should, as far as possible, not be disadvantaged through oligopolistic pricing of inputs and South Africa's distance from alternative suppliers. They should charged*

the export parity price or profit parity price (profit parity between export and domestic markets) or, even cost plus reasonable return. Beneficiation projects should be required to provide pricing structures that will at best favour the local fabricator, or are at least neutral with regard to export price structures, to qualify for capital expenditure write-off schemes or any other state incentives or support.

- 2. Qualification for tax concessions and finance for beneficiation projects should require advantageous domestic pricing such as export parity prices for local fabricators.*
- 3. A small levy, payable on unbeneficiated ores which are exported, could be considered to encourage their local beneficiation. The levy levels could reduce depending on the level of beneficiation.*
- 4. Tax breaks are often necessary to make large beneficiation projects viable due to the long lead times to earnings in the context of high inflation. Features of the current tax regime applicable to capital expenditure for gold mines in which capex tax credits may be brought forward in their entirety with a consideration for annual inflation, should be extended to cover mineral beneficiation projects, but carried forward at actual inflation rather than an arbitrary consideration. The application of these provisions to cover all ex-mine value adding processes that terminate with the production of dimensional products should be investigated.*
- 5. The state through the Department of Trade and Industry and development finance institutions, in particular the Industrial Development Corporation, should give emphasis to supporting downstream industries able to exploit the opportunities created by the availability of competitively priced inputs from beneficiation projects.*
- 6. The state through the Department of Finance and the Reserve Bank should take steps to lower economic and fiscal uncertainty and permit long term planning to be undertaken, crucial for projects of the magnitude of mineral beneficiation projects. By lowering the risks involved in launching beneficiation projects the returns required by providers of capital are lowered and the financing costs correspondingly reduced.*

4.3 Analysis of proposed policy

Before beginning the analysis of the proposed policy it is worth noting that although there is extensive mention of optimality and sustainability in the ANC's discussion document, there is no attempt to define what is meant by these terms. To avoid this limitation, this chapter will use the

Hartwick definition of sustainable utilisation of non-renewable resources, and will use the benchmark case described in chapter two as the definition for optimal extraction.

There is a proposal at the end of the discussion document that fiscal and monetary policy be used to lower uncertainty and to encourage long term planning. Such risk reduction would mean lower required rates of return and lower financing costs. While these policies would have a positive effect on the mining industry, resulting in a move towards optimality in extraction and investment, they are general macroeconomic policies which should be a goal of any government at all times, and not be seen as existing for the benefit of one sector.

4.3.1 Environmental policy

The ANC environmental policy as it pertains to minerals concentrates on five basic themes; pollution and the rehabilitation of mine land, the role of small-scale miners, community consultation, water management, and the policy making process. Of these the theme that receives the most attention is pollution and the rehabilitation of mine land, this is also the area of policy that is most likely to have the greatest impact on mining.

The ANC has proposed that the benefits from mining be balanced against all the costs that result from extracting a body of ore, including those of pollution and rehabilitation. This means that there is move towards recognising that environmental degradation due to mining represents a cost to society that must be internalised into the mining decision. The gap between marginal private and marginal social costs must be closed in order that the extraction of minerals be truly socially optimal. With the internalisation of externalities, the private costs of extraction will be raised, raising the grade of the lowest payable ore quality, which in turn means less ore extracted and the life of the mine shortened. Despite the fact that this result is contrary to the stated ANC goals, it is a move towards extraction optimality as defined above.

The proposed changes to the rehabilitation fund will turn the required payments into the equivalent of a severance tax³³. The same may be said of the proposed levy to pay for past damage and cases where the damaging party cannot be identified.

³³ The effects of a severance tax as described by Heaps (1985) are described in chapter two of this paper.

The proposed streamlining of the policy making process as well as the desire to comply with international norms should help to reduce uncertainty in the minerals industry and reduce bureaucratic costs. These effects should serve to make investment in the minerals industry more attractive and efficient, possibly culminating in more mines coming into production. Additionally, with the adoption of international environmental standards, the South African minerals industry would not need to fear the imposition of punitive tariffs on its exports by countries which demand higher environmental standards from their own mining industries³⁴.

With respect to small scale miners, the proposed environmental education policy would reduce the number of small scale miners meeting the requirements for a mining licence by effectively raising its price. The proposal for increased state management in areas where small scale mining is concentrated may help to lower the costs faced by such miners if one takes an optimistic view of state involvement.

In all, the proposed environmental policy for the minerals industry will have at least two effects:

- 1) to raise costs as externalities are internalised to the mining industry, and
- 2) to reduce uncertainty as policy changes become more transparent and fewer departments have overlapping or contradictory legislation.

Both these effects should help to promote the optimal extraction of the nation's resources.

The increased investment due to the lowered uncertainty, and the increased exploration due to the decline in payable reserves³⁵ (due to raised extraction costs) should help to offset any negative effect the shortening of mine life spans and the raising of costs may have on both tax revenue and employment.

³⁴ This sort of punitive tariff is increasingly being used to circumvent GATT requirements.

³⁵ The rise in costs due to the internalising of environmental costs results in the mines having to raise the average grade of ore they mine in order to maintain a constant return on capital. This means a rise in the lowest payable grade of ore. (The formula tax would counter this effect if extended to all mines.) This may imply a large reduction in payable reserves as there are often larger reserves of lower grade ore than of higher grade ore. A major decline in payable reserves gives an incentive to invest in exploration in order to raise the stock of payable reserves.

4.3.2 Mineral tax policy

The ANC has proposed a number of changes to minerals taxation, of these the most important are probably the proposed minerals rights tax, the extension of formula taxation to all minerals and the extension of the capital allowance and redemption systems to all mining and beneficiation projects. These proposed changes will be the focus of this section.

Other proposals are the small levy on tonnage depleted (a severance tax), the beneficiation levy and the reassessment of ring-fencing. The last of these could be seen as an element of the proposal to extend the capital redemption and capital allowance systems, as can be the proposal of the possibility of greater than 100% write-offs to attract investment to the mining sector.

The ANC document offers no indication as to the purpose of the levy on tonnage depleted, although it may be related to the proposed environmental protection levy discussed above. The depletion levy is a severance tax which will raise the lowest payable grade of ore that will be mined. The result of such a tax, as indicated by Heaps (1984)³⁶, is that less ore is extracted and as a result the life of the mine is shortened. If the lifespans of the mines are adversely affected, one would expect a negative impact on employment in the mines. If the levy is, however, aimed at forcing the internalisation of externalities it would be encouraging mines to extract ore in a socially optimal manner despite the negative effects. The revenue generated by the levy would then be compensation for the environmental resources used during the extraction process, not for the ore extracted, and could thus not be considered as part of the rents generated by the mining process.

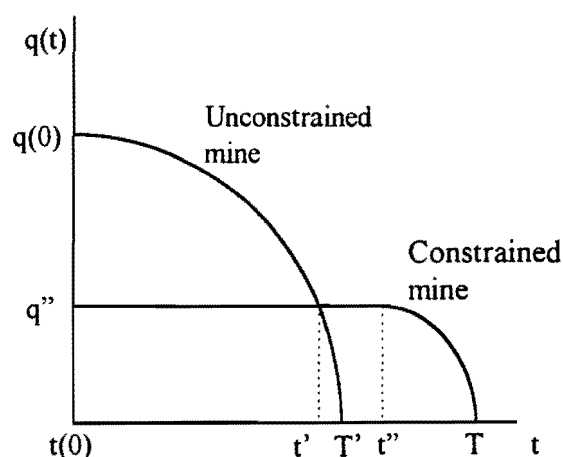
The beneficiation levy would be charged on unbeneficiated ore exported, the size of the levy declining as the level of beneficiation of the exported mineral increases. This levy is essentially the same as that on the export of uncut diamonds and is ostensibly meant to encourage domestic beneficiation. The success of the ANC's policy in this regard will depend on far more than just this levy. These other factors will be addressed in the section on beneficiation and domestic input pricing policy below. Any beneficiation project that is initiated will take some time to come on stream, and domestic exporters of unbeneficiated ore will be disadvantaged by the levy until the domestic beneficiation capacity increases. The levy will cut into domestic producers' profits as

³⁶ See chapter two.

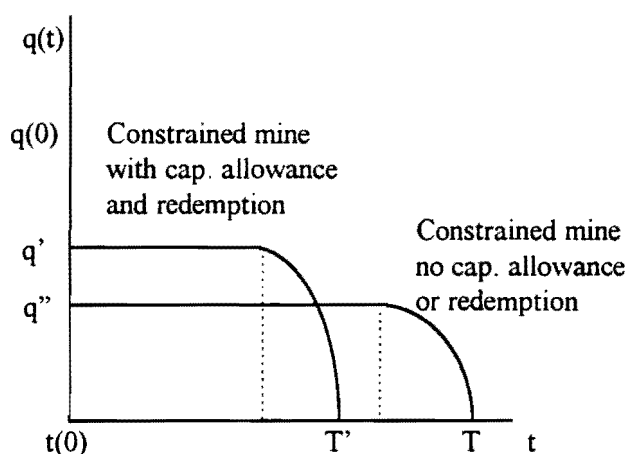
they are generally price takers. The levy thus has the same effect as a cost increase. It is in effect a severance tax which will serve to raise the grade of the lowest payable ore, shortening the life span of the mines it affects and negatively affecting employment. This effect will remain as long as some part of the ore extracted is exported in unbeneficiated form

At a macroeconomic and welfare level it is possible that these losses will be outweighed by the increased employment in beneficiation industries and the wealth these industries will bring to the country by increasing the level of domestic value added. From a revenue perspective, the levy will generate positive net revenues for as long as local ore production greatly exceeds local beneficiation capacity. It is possible that as long run revenues from the levy decline due to higher levels of local beneficiation, these revenue losses will be offset by the broadening of the tax base.

The proposed extension of the capital allowance and capital redemption systems to all mines and beneficiation projects, and the proposal that the capital allowance be increased by permitting the value of tax deductible capital to increase at the rate of inflation, affect the extraction rate directly and indirectly. They affect the extraction profile of individual mines by influencing the capacity constraint that physical capital imposes on the mines. Since capital is not free, the mine owner invests in capital until the change in the present value of the mine as a marginal unit of capital is added to the mine equals the cost of adding that unit. The level of capital invested in the mine thus determines the maximum amount that can be extracted from the mine at any point in time. Consider the diagram below:



A mine unconstrained by capital costs (as posited by Hotelling) would invest enough to begin extraction at $q(0)$, and follow the unconstrained extraction path to terminal time T' . A mine constrained by capital costs, however, would invest only until the optimal condition for investment described above is met. In general, this will not be enough to extract $q(0)$ in the first period. (Why have excess capacity for the rest of the mine's life?) If only enough capital to extract initial amount q'' is invested, then the mine follows the constrained extraction path to terminal time T . Assuming the same total amount is extracted, T is greater than T' , and t'' the time at which the constrained mine stops operating at capacity can also be shown to be greater than T' . Hartwick and Olewiler, (1986). The constrained path can then be seen as the optimal path in the light of capital costs. If the cost of capital in the mining industry is reduced, the capacity of the mine would be increased as the capital constraint is eased. The extraction path resulting is shown below:



The extraction rate is raised as the capital constraint is eased, and the terminal time is drawn forward. Thus if all other conditions remain unchanged, the capital allowance and redemption systems speed up extraction in individual mines and shorten their lifespans.

These proposals further influence extraction patterns indirectly by lowering the cost of capital in the mining sector, and lowering the risks involved in investing in mining and beneficiation, i.e. by affecting the rates of entry and exit into the industry. It achieves this by reducing the time it takes to recoup capital expenditure. It encourages investment as investors know the income generated by their capital will only be taxed after the initial outlay has been recouped. However, by lowering the cost of capital in one sector, government distorts the investment patterns of the economy as a whole. Investment funds are attracted to the minerals industry at the expense of other sectors of the

economy. The artificial attraction of the sector results in the inefficient allocation of factors of production. The end result is excessive investment in the minerals sector, to the detriment of the economy as a whole. As the cost of capital in the minerals sector declines and the level of investment increases, so the national rate of extraction of ore increases. As is argued in the chapter above, this lowering of the cost of capital places a wedge between the rate of interest the mines use for their extraction decisions and that used for their investment decisions. There is thus no balancing effect as described in appendix A to prevent a private rate of discount higher than the social rate leading to excessively high extraction rates. In effect the divergence between private and social rates of discount is aggravated and a gap opens between the actual and socially optimal rates of extraction.

As more mines are brought into production (the cost of entry is reduced) and extraction rates at every individual mine increases, the mineral resources of the nation are depleted more rapidly than is socially optimal. In the short run of course the employment level will be raised as mining activity increases, but this will last only as long as the mines are producing. This will not be a problem if the state favours current over future employment.

More rapid extraction also means more environmental degradation in a shorter time, while increased levels of local beneficiation imply increased levels of local pollution.

An increase in the capital allowance and the extension of capital redemption and capital allowance to all mines and beneficiation projects will mean a decrease in tax revenues in the short run, until new investment broadens the tax base. This was the fear which was realised in the early eighties and resulted in the introduction of the ring-fencing system. This prevented mines writing off capital expenditure in the first year of production against income generated by other mines in the group. As a result, the cost of capital was effectively raised to some extent, adversely affecting the mining houses' returns, but protecting part of the government's tax revenues.

The proposed mineral rights tax is aimed at encouraging the return of mineral rights to the public domain in order that the state may extract a rent or royalty from the mining companies who wish to mine a resource. It is also aimed at freeing up mineral rights which are not in use so that others may be given the opportunity of utilising these resources. It further proposes that exploration

expenditure be deductible against the tax. This is intended to encourage the holders of mineral rights to use them. Where the rights are not being used, it should be worthwhile for the owners to relinquish them to the state, helping to free up rights for new investors and small scale mining ventures. Where the rights are being used, and there is no new exploration being undertaken, such a tax will simply raise the marginal tax rates faced by mines, making further investment less attractive and cutting into profit margins. Lower profits means a raised lowest payable grade, and a shorter life span for the mine, i.e. there is a direct influence on the extraction profile. Heaps (1984)

Revenue is not the primary goal of the proposed mineral rights tax, and it is unlikely that much will be generated as it achieves its primary goals of increasing exploration and returning mineral rights to the state. The return of these mineral rights to the public domain will create the potential for future revenues to be generated from lease payments by those wishing to use them.

The formula tax system creates distortions in the mining process encouraging the non-optimal use of resources, thereby driving a wedge between the private and social benefits of mining. The effects of the formula in the gold mining industry have been described in some detail in the previous chapter and will be formalised in appendix D. Extending it to other minerals will increase the waste of resources by inducing the mining of sub-marginal ore grades. The result will be a fall in revenues accruing to the fisc as rents are sacrificed through the mining of lower grade ore, and the compromising of sustainability and intergenerational equity as less rent remains available to be invested in renewable capital. It is ironic that the aim of the authorities introducing the formula tax was to lengthen the lifespan of the mines in order to promote sustainability and equity!

As lower grade ore is mined there is more waste per unit of final output, meaning a greater environmental toll for less benefits. The volume of ore that is extracted and processed in order to extract a unit of pure mineral is greater the lower the grade of the ore. The amount of waste remaining after processing is greater, and the benefits generated from it are less. Thus, the net social benefits from mining a unit of lower grade ore are less than from a unit of high grade ore, and may even be negative.

4.3.3 Mineral rights policy

The ANC's mineral rights policy centres on security of tenure, the return of mineral rights to the state, the encouragement of use of mineral rights and the freeing up of mineral rights in order to encourage the competitive use of the nation's mineral resources.

South Africa finds itself in a position where the major mining houses hold large amounts of unused mineral rights, making it difficult for new entrants to the sector to obtain exploration and mining rights. (The situation has been likened to a cow in a lush green pasture that stretches its neck out over the fence to eat the growth it does not own while saving that which it does. Kruger and de Wit (1987)) There are indications that South Africa, unlike other African states, is missing out on a mining exploration boom in Africa because of, amongst other factors, the unavailability of mineral rights. Ryan (1995). The ANC feels that this problem is due to the mining houses sitting on mineral rights which could be exploited by other companies, and needs to be addressed quite urgently. It is hoped that the proposed mineral rights tax will achieve this.

The mineral rights tax should free-up unused mineral rights, and encourage exploration activity if exploration expenditure can be deducted from the tax. It should also encourage competition in the industry as new large investors as well as small scale miners can obtain mineral rights. This may negate the need for any anti-trust legislation in the mining sector.

If the tax were levied on rights currently in use, it would simply raise the marginal tax rate on mine income. This would make the South African minerals sector less attractive to investors, who would invest elsewhere.

In the introduction, mention was made of the single land tax and its similarity to the expropriation of land by the state which would then let it to tenants for an amount equal to its economic rent, allowing a reasonable return on investment and the recovery of interest and requiring payment of the excess. This is essentially what the ANC proposes in the case of the mines. If the state held the rights to all minerals, it could let these in return for the mineral rents to those who wish to mine. The parties who invested in the mining operation would be allowed to recover their capital and a reasonable return on it, and any excess revenue would be paid to the state. In this situation however any other tax on mine income would reduce the return on capital that was deemed to be

'reasonable'. There is a problem with determining the return to various factors of production, especially capital and entrepreneurial risk. This is especially true in the extractive industries where there are high levels of risk and the return on capital including the risk premium must be separated from the economic rent. It would thus be difficult to determine what a 'reasonable' return should be.

As long as the state has the right to tax it has the ability to extract the rents generated by mining, without itself owning the mineral rights. Hence it is not clear that it is necessary for the state to hold the mineral rights in order to extract rents. The extraction of rent is thus no reason for the state to require the return of mineral rights to the public domain.

Beyond the need to capture rents, the ANC appears to believe that the return of mineral rights to the state is necessary to encourage the use of mineral rights and the competitive use of the nation's mineral resources. While private ownership of mineral rights is not common amongst other mineral rich nations, it is not clear that private ownership in itself prevents the optimal exercise of such rights. The mineral rights tax should induce a market in mineral rights, where unused rights can be sold, or leased to those willing to utilise them.

An advantage of having mineral rights privately held is that the state does not need to be concerned with guaranteeing security of tenure; an issue which the remainder of the mineral rights policy attempts to address.

Although it is doubtful that the mineral rights tax will induce the holders of such rights to return them to the state (they could just as easily avoid the tax by selling unused rights to parties willing to use them), the state still has to ensure security of tenure for those wishing to mine where it holds the mineral rights. The recommended policy of guaranteeing tenure for as long as is necessary to ensure optimal use of the mineral resource is a positive one, as are the other proposals pertaining to the allocation of licences. These policies should help to reduce the levels of uncertainty faced by potential investors, and speed up the process of granting of licences (as fewer departments would be involved). Both of these effects should encourage investment and optimal extraction, as well as aiding in the employment creation process. Care must be taken, however, to avoid companies merely making the minimum use of the rights necessary to secure these for future usage.

The mineral rights policy proposed by the ANC appears to be sound and to encourage optimal investment in mining and extraction of minerals. The only doubt attaches to the return of mineral rights to the state, which need not be a prerequisite for attaining the other positive goals set out in the policy statement. Besides this one exception, the policy should successfully reduce government induced uncertainty and market induced monopoly of ownership of rights, resulting in a move towards more optimal investment patterns and extraction paths.

4.3.4 Beneficiation and domestic raw materials pricing policy

Beneficiation and pricing policy centre on the beneficiation levy, the extension of the capital allowance and capital redemption, and 'fair' domestic pricing strategies. The first two were discussed in the section on mineral taxation, this section will focus primarily on the last mentioned.

The ANC's pricing policy states that local fabricators are not to be disadvantaged by oligopolistic domestic pricing of inputs and distance from alternative suppliers. They should be charged export parity price or profit parity price (profit parity between export and domestic markets) or even cost plus reasonable return. These policies, although vague, appear to be aimed at preventing domestic mines from charging domestic fabricators the f.o.b. price plus transport costs. One way to achieve this, according to the discussion document, would be to require suppliers to provide pricing structures that best favour local fabricators in order to qualify for the capital allowance and redemption schemes.

This policy is unlikely to have any significant effect on local extraction patterns as the reduction in extra profits due to charging transport fees should be minor. It will, however, provide support for domestic industry and employment. It will thus augment the proposals for support for downstream industries capable of taking advantage of competitively priced inputs.

An issue that is not addressed in the discussion document is that of comparative advantage. This issue is especially relevant to the beneficiation levy. It may be that in some sectors of the South African minerals industry there is no comparative advantage in beneficiation. This may be due to a shortage of the factors of production used in the beneficiation process, or simply because the levels of productivity possible in this country are below those of competing nations. In these situations,

both the levy and increased domestic beneficiation would be harmful to our international competitiveness.

4.4 Description of conflicts in policy and objectives

There are a number of conflicting policy objectives set out in the discussion document which will need to be resolved before any final policy is legislated. The most obvious of these conflicts in goals is the desire to encourage optimality of extraction, efficiency, sustainability and the mining of the lowest possible ore grade. To encourage the last of these is to compromise the first three. They cannot be attained simultaneously. The reasons for this are explained in the sections above which discuss the formula tax system. To reiterate, by encouraging the mines to extract a grade of ore which is not worth the cost of extraction, by subsidising the loss out of rents, the state is encouraging the waste of resources today out of funds meant to compensate future generations for the extraction of ore. This includes generations that come after the mines have closed, no matter how long that date is postponed by the tax.

This means there is also conflict between the revenue objectives of the state and the formula tax system. There is a need for revenue to finance the RDP, and the ANC has expressed a desire to increase state revenues from mining operations. This is in conflict with the formula tax system, which subsidises the waste of resources out of potential tax revenues as described in appendix D. There is a link between revenues and sustainable development (as defined by Hartwick, 1977) in the form of the RDP. The RDP is aimed at the financing of housing, infrastructure and human capital; types of investment that sustainability demands. It is therefore inconsistent that rents from the mineral industry are spent on current employment and wasted resources.

The encouragement of the extraction of lower grades of ore is in conflict with the environmental concerns expressed by the ANC. The environmental policy is likely to encourage an increase in the lowest payable grade by bringing private costs into line with social costs, while the formula tax system used to encourage the extraction of low grade ore places a wedge between them.

The capital allowance and capital redemption systems are partially in conflict with revenue objectives. Only partially because the capital allowance and redemption systems encourage investment, and thus broaden the tax base. The ANC's policy on ring fencing does indicate some

concern about revenue in the short run, with a cautious attitude being taken towards the removal of the fences.

The policy which is most at odds with the ANC's objectives is that of encouraging the extraction of sub-marginal ore grades via the formula tax system. The policy suggestion that this system be extended to all mines is in conflict with the environmental goals, the goals of sustainability and optimality, the revenue needs of the state, as well as the efficiency goals towards which the ANC purports to strive.

5. Conclusion

South Africa has entered a transitional phase and the minerals sector has not escaped the attention of those bringing about the changes. South Africa is a mineral wealthy nation and the people of the nation should benefit from this wealth. It is the ANC's stated intention to maximise the mineral industry's contribution to the reconstruction and development of the nation. It has been the intention of this paper to analyse the policies proposed to achieve this goal and decide whether or not they will be effective.

5.1 Summary of Results

The ANC's proposals as they pertain to the minerals industry have been presented and analysed in the preceding chapter. A summary of the conclusions arrived at are presented below.

1. The environmental policy consists of methods of reducing externalities by forcing the internalisation of all production costs, and of reducing uncertainty due to policy conflicts or lack of clarity. The objectives are sound and the proposed policies should be effective in attaining them. The effects on the mineral industry are twofold.

Firstly the raised costs as externalities are internalised will reduce the lifespans of the mines as unit costs of extraction are raised (the same effect as a severance tax). They will also lower the expected returns on new mines, thus reducing investment in exploration and the development of new mines.

Secondly, the reduced uncertainty from clearer policies should reduce costs associated with risk (such as financing costs) and encourage investment.

Whether the effects on extraction of these two policies cancel each other out will depend on a number of factors and is uncertain. What is certain, however, is that the net effect will be beneficial to the environment and the economy as externalities are reduced and there is a move towards greater optimality (due to a reduction in externally imposed uncertainty and the closing of the gap between private and social costs) in the minerals sector.

2. The mineral rights policy is aimed at freeing-up mineral rights, assuring security of tenure and returning mineral rights to the public domain in order to extract economic rents and encourage the use of the mineral rights. The policy instrument suggested to achieve the first and the last of

these is the mineral rights tax. The mineral rights tax should be effective in achieving the first objective, i.e. the freeing-up of rights, but it is not clear that it will achieve the second. It has been argued in this paper that it is not necessary that the objective of returning mineral rights to the public domain be achieved, as all the perceived benefits of state ownership can be obtained under private ownership, without encountering the security of tenure problems of state control.

The mineral rights tax on deposits currently being exploited will raise the average tax rate faced by mines. This will reduce expected returns from mining and discourage investment in exploration and the development of new mines. Where it is charged on unused claims, it will encourage the owners to either use the claim, let or sell it to somebody else who wishes to use it, or abandon the rights to the state.

The aim of the mineral rights tax should thus be the creation of a market in mineral rights, which will free up rights and encourage exploration and investment. If it succeeds in this goal, it will encourage a greater level of competition and activity in the domestic minerals market. More competition would help achieve the goal of optimal extraction, while more activity will lead to more employment in the minerals sector. The tax would also generate revenue in the short run while helping broaden the tax base in the long run.

With respect to security of tenure on state land, the proposed policies should encourage optimal extraction and investment process, by reducing risks associated with security of tenure and encouraging competition, while simultaneously aiding the employment creation. This should be the result as long as any freezing of rights by companies (by engaging in minimum usage of rights granted to them) is avoided.

3. Beneficiation and domestic input pricing policy is aimed at encouraging greater levels of domestic beneficiation and fabrication. The policy instruments proposed to achieve these goals are a beneficiation levy on exports of ore, the extension of the capital allowance and capital redemption systems to beneficiation projects, and the withdrawal of tax incentives from companies which price their output in a manner which penalises local fabricators.

The above policy instruments (with the exception of the levy) should not have any effect on the mining industry. The levy, however, will reduce the profits of domestic producers of ore as they are generally price takers and unable to shift the levy onto foreign beneficiaries. The levy becomes a severance tax which shortens the lifespan of mines and negatively affects employment. In addition, as long as some ore is exported unbeneficiated, the expected returns from mining are reduced, reducing the incentive to invest in the mining sector. These negative effects may be more than offset by the gains from increased domestic beneficiation.

There is, however, no certainty that the levy would encourage increased domestic beneficiation as there are a number of other factors to be considered. The most important of these is comparative advantage. Before encouraging investment in beneficiation projects by reducing the cost of capital and imposing levies, it must be asked whether domestic beneficiation is viable. The beneficiation process may require inputs that need to be imported, or factors of production that are not as productive in South Africa as elsewhere. In this situation it may be detrimental to the economy to initiate a project which would be uncompetitive in international terms.

With respect to pricing policy, it may be worth considering policies which will encourage competitiveness in the domestic minerals markets in order to achieve the pricing goals. The mineral rights tax would be one such policy.

4. The remainder of the minerals policy proposed by the ANC focuses on the lowering of capital costs to encourage investment in mining, and on the encouragement of low grade mining in order to increase the lifespans of the mines and increase employment levels. The proposed policy instruments to attain these goals are,
 - a) the extension of the capital allowance and capital redemption systems to all mines, and
 - b) the extension of the formula tax system to all mines.

The extension of the capital allowance and capital redemption systems could have serious consequences for government revenue, ore extraction paths and lifespans of individual mines, investment patterns, employment, and the lifespan of the nation's mineral resources.

Looking at the first of these; by allowing the capital expenditure on a mine to be written off against income in a single year (or any shortened period), the state is sacrificing revenue. Even if these revenue losses are acceptable to the state in order to increase the level of investment in the mining industry, there are the problems associated with the increased investment.

The lowering of the cost of capital in one sector of the economy, *ceteris paribus*, creates distortions as capital is drawn to that sector at the expense of others. The increased levels of investment are not limited to new ventures, but also serve to reduce the capacity constraints imposed on existing mines. This speeds up extraction and, assuming all else constant, shortens the life of the mine. Employment on any mine increases, but the duration of that employment is shortened. Levels of employment are similarly increased in the short run by increased investment in new ventures. Again this is short term as the life of the state's mineral resource as a whole is shortened by the combined effect of more mines and faster extraction in each mine. A higher level of environmental degradation would also be associated with this faster extraction.

Looking at the question of sustainability, the attraction of capital to the mining sector at the expense of other sectors of the economy means that more capital is invested in forms of capital which have no residual value once the ore reserves have been exhausted, such as sinking shafts (a sunk cost if you like), and less in renewable capital. Future generations thus inherit less renewable capital, and more holes in the ground.

The extension of the formula tax system to all mines would have similar results. The formula tax system encourages the mines to waste resources in order to mine low grade ore, or to mine deeper lying ore, thus lengthening the life of the mines and maintaining employment. The wasted resources are in effect wasted rents. The state is thus sacrificing rents (revenue) in order to lift employment levels and standards of living today. In terms of sustainability and intergenerational equity, this amounts to theft. Not only do future generations (those generations that come after the mines have closed) have less ore in the ground, but the compensation they should have received in the form of renewable capital for the removed ore is reduced.

Proponents of the formula tax and the encouragement of low grade ore extraction will argue that the waste of resources and the sacrifice of rents is justified by the objectives of maximising

lifespans and increasing employment. They may argue that by mining ore which would otherwise not be extracted the benefits from the mine are maximised. The rebuttal is easy, the optimal extraction of ore as described in the benchmark case in chapter two maximises the benefits to be obtained from mining. This was the result that Hotelling proved in 1931. The benefits cannot be increased by sacrificing rents in order to mine uneconomic ore reserves.

The employment creation argument shows that the formula tax is, in effect, a public works program, with the government subsidising the digging ditches worth less than they cost. The RDP and sustainability (as defined by Hartwick in 1977) would be better served if the rents from the mines were used on public works programs aimed at improving infrastructure, building roads and laying water and sanitation systems, rather than digging deeper mines.

There are also the added environmental costs associated with lower grades of ore being mined, there is more waste for less output. In the case of gold mines this has meant cyanide slimes dams, arsenical waste and dumps.

In view of the costs associated with the formula tax, the proposal to extend it to all mines must be reconsidered. Revenue, environmental, sustainability and optimality goals would be better served if it were not extended, and perhaps even removed from the gold mines.

To sum up then, the environmental policy is sound and the instruments proposed should achieve the goals set, while simultaneously encouraging optimality. The mineral rights policy, with the exception of the goal of returning rights to the public domain, is also sound and should encourage optimality in investment and extraction. The beneficiation and pricing policy need to be re-examined, as the latter can be achieved with other policies and the former may bear more costs than benefits. The proposed extension of the capital allowance, capital redemption and formula tax systems to all mines would increase existing distortions in extraction rates, further compromise sustainability and environmental policy, and would reduce revenues to the fisc.

In view of the distortions created by the formula tax, the capital allowance and the capital redemption facility, as well as the conflict between these instruments and other policy objectives, it is recommended that they not be extended to other mines. It is also recommended that their

application to the gold and platinum mines be reconsidered in favour of a neutral, flat rate profits tax.

5.2 Conclusions

Amongst the tasks facing the ANC and Government of National Unity is that of extracting the maximum amount of economic rent from the mining sector while operating within a series of constraints. These constraints include competition for international investment capital, pressure from domestic mine labour unions, environmental concerns, optimality and efficiency concerns, as well as desires for equity and redistribution.

Pressure from the unions will be brought to bear on the GNU to maximise the *current* benefits to members by improving working conditions and wage rates. As such, the unions are likely to place more emphasis on current rather than future employment. Union support for the extension of the formula tax to all mines would thus be consistent with their goals as it induces the transfer of a portion of the economic rents to current labour. It would also be consistent for the unions to favour the extension of the capital allowance and redemption systems as these will shift the labour demand to the right, raising employment levels and/or wage rates. It is unlikely that labour will be in favour of any policy (such as the environmental policy) which will reduce the mines' lifespans and lead to a reduction in employment or wages in the short term.

The environmental lobby will be pressing the state to introduce policies which favour the environment despite opposition from organised labour. The green movement is an international one, and cannot be ignored. There is a possibility of punitive trade tariffs being introduced against any country which does not meet international environmental protection standards. It would be consistent for environmentalists to pressure government for the removal of the formula tax and reconsideration of the capital allowance and redemption policies in light of the detrimental effects these have on the environment.

Beyond the lobbying of these two opposing groups, the state must consider optimality, efficiency, equity and redistribution. Fundamentally, this is the growth vs. redistribution argument with a twist. In the case of growth generated by the extension of the formula tax, the capital allowance

and the capital redemption facility, growth does not result from efficiency and optimality. Rather, it results from a redistribution of benefits from future generations to current ones. Equity and redistribution between generations as well as within generations is best served by optimality of extraction. The formula tax, the capital allowance or the capital redemption systems are not consistent with these goals.

International competition for investment capital constrains the amount of rent that can be extracted by taxation (or any other means) rather than the means of rent extraction. While an increase in the average rate of taxation faced by an existing mine will not alter its extraction profile (as long as the tax is neutral), it will reduce expected returns from new investment and thus reduce the incentive to invest. In an international context, if South Africa wishes to remain competitive in the market for new investment capital, average tax rates cannot be raised much higher than those faced by capital invested in mining elsewhere in the world.

The constraining factors described above will determine which policies are implemented and which are not, which will in turn determine South Africa's international competitiveness and levels of social welfare, present and future. The formula tax, the capital allowance and the capital redemption policies are not consistent with the objectives of government. Even labour is harmed by these policies in the long run. All parties will lose in the long run if they are implemented, leading to the conclusion that it would be a mistake to do so.

Appendix A

There is some uncertainty surrounding the effects of a divergence between the private or market discount rate and the social rate. It has been suggested by conservationists that private rates of discount are generally higher than the social rate, and that this results in greater than optimal extraction rates. Their argument is that with a higher interest rate or discount rate, the resource owner faces a higher opportunity cost when leaving ore in the ground. The higher the private rate of discount the greater the present value of the resource once extracted, sold and converted into an interest bearing asset. Hence the owner's incentive to speed up extraction.

This argument would be robust, but for the relationship between interest and investment, and the observation that higher extraction rates require more capital equipment, and thus more investment. (Additionally, the marginal cost of production tends to rise as extraction rates increase, which would have a dampening effect on the incentive to increase the extraction rate.) Mining, especially at deep levels, is capital intensive, from the exploration stage right through to final production. Before an increase in investment in such a project is undertaken, the project must be expected to offer an internal rate of return equal to or greater than the market interest rate. Thus, as interest rates rise, it becomes more difficult for new investment in a given project to satisfy the criteria necessary for viability. I.e. in mining, as elsewhere, the marginal efficiency of investment and marginal efficiency of capital schedules are negatively sloped.

If the private discount rate is in fact higher than the social discount rate, then the effects are:

- 1) to reduce the amount invested in mining, but
- 2) to speed up extraction at developed sites with existing capital.

Obviously the effect of less investment in mining is that fewer mines will be developed. There are thus fewer mines than there would be if the social discount rate were used, extracting faster than would be the case if the social rate were used. The net effect then is ambiguous, and depends on the elasticity of the investment schedule.

If the effect of lower investment in exploration and new mines outweighs the higher extraction rates, then the net effect of an increase in interest rate will be that less is extracted than is socially optimal

Appendix B

As indicated by the tables in appendix C, South Africa has large reserves of many minerals, and in some cases (such as platinum) dominates the world's mineral reserves. This puts South Africa in the unique position that as a nation it has the ability to exert some monopoly power in certain of the world's minerals markets. It may even be argued that it would be in the nation's best interests to encourage the exertion of what monopoly power we have in order to maximise the rents obtainable from the nation's resources. With the exception of the diamond market, this power is not exerted, as a result of competition between mines domestically.

There is of course the counter-argument that such power cannot be guaranteed in the long run, and that the incentive to engage in minerals exploration overseas provided by such monopoly prices may result in discoveries that undermine the profitability of our own mines, resulting in a net reduction in rents accrued. This was the fate of Jamaican bauxite, although the circumstances were slightly different in that situation (the foreign exploration was prompted by lower profits due to increased rent payments to the state, not due to monopoly extraction rates).

While the ownership of mines in South Africa is relatively diluted, control is highly concentrated. This is due to the system of corporate governance in South Africa whereby the founder of a company can maintain control of the company while reducing the proportion of his/her holding in the company by establishing a pyramid of holding companies. (See Barr, Gerson and Kantor 1995 for an explanation of this system and its pros and cons.) The mines are thus, in effect, controlled by a small number of groups or individuals, and there may consequentially be an element of monopoly in the mining industry domestically. This however does not imply an ability to control world prices. Control over world prices would be a prerequisite for the utilisation of any monopoly power and the slowing of production this would imply. As indicated above, such control may be possible in the cases of some minerals in the short run, however, long run control is dubious as monopoly profits encourage exploration elsewhere.

Even in the case of diamonds there is some doubt about the effect of concentration on extraction. There is no denying that DeBeers controls the world price of diamonds through its Central Selling Organisation. The CSO acts as a monopsonist as well a monopolist, and does not control

extraction from all mines. It is thus unclear whether there will be an incentive for individual mines to slow down production to monopoly levels.

Appendix C

Importance of South African reserves in a world context

Mineral	Reserves	%West	%World	Rank*
Manganese (metal)	4.0 Gt	90	82	1
Platinum Group Metals	30.2 kt	85	78	1
Chromium (ore)	2.4 Gt	58	56	1
Vanadium (metal)	7.8 Mt	47	1	
Gold (metal)	20.0 kt	44	1	
Alumino-silicates (ore)	51.6 Mt	37	1	
Diamonds	360.0 Mcts	27	24	2
Zirconium (metal)	6.9 Mt	16	4	2
Uranium (metal)	317.0 kt	13	N/A	3or 4
Fluorspar (CaF ₂)	32.0 Mt	30	11	3
Titanium (metal)	31.1 Mt	12	11	4
Coal (recoverable)	58.4 Gt	20	10	4
Nickel (metal)	11.4 Mt	12	10	6

South African Production in a world context

	SA Production as % of World 1989	Rank
Manganese metal	68	1
Alumino-silicates	47	1
Vanadium	44	1
Vermiculite	41	2
Chrome ore	31	1
Gold	30	1
Ferrochromium	29	1
Titanium minerals	26	2
PGM	21	3
Manganese ore	19	2
Zirconium minerals	16	2
Ferromanganese	10	3
Diamonds	10	5
Antimony	8	4
Fluorspar	6	5
Coal	5	6
Silicon metal	5	7
Asbestos	3	7
Iron ore	3	8
Ferrosilicon	2	8
Phosphate rock	2	9
Lead	2	12
Copper	2	14
Silver	1	14
Zinc	1	16
Uranium	na	7

South African Exports in a world context

	SA Exports as % of World 1989	Rank
Vermiculite	92	1
Vanadium	83	1
Alumino-silicates	67	1
Manganese metal	60	1
Ferrochromium	47	1
Manganese ore	31	1
Ferromanganese	28	1
PGM	27	3
Chrome ore	26	1
Titanium	22	2
Zirconium	22	2
Lead	13	3
Coal	13	3
Antimony trioxide	13	4
Asbestos	11	4
Fluorspar	10	4
Iron ore	4	7
Phosphate rock	3	10
Silver	2	11
Ferrosilicon	2	13
Copper	2	13
Zinc	1	14
Antimony concentrate	0.3	10
Gold	na	1
Silicon metal	na	7
Diamonds	na	

Role of Minerals in South African Exports

Commodities	Value (R million)	% Contribution to Total Exports
Gold	23236.3	29
Diamonds	9480.6	11.9
Metallic	6169.6	7.7
Coal	5227.8	6.6
Platinum	5188.8	6.5
Metal ores	3740.6	4.7
Non-metallic	1602.5	2

Appendix D

A numerical description of the effects of the gold mining tax formula (adapted from the Margot Commission of Inquiry 1987).

The tax formula is:

$$Y = A - AB/X \quad (0)$$

where Y is the tax rate as a percentage of profits, A = 60 and B = 6 or 8 depending on the age of the mine (6 for pre-1966 mines and 8 for post-1966 mines). X = the ratio (expressed as a percentage) of profits to revenue.

If we call revenue R and costs (including capital expenditure) C, then profits will be (R - C) and

$$X = 100(R - C)/R. \quad (1)$$

If we call the tax payment T then

$$Y = 100T/(R - C). \quad (2)$$

Substituting (1) and (2) into (0) gives the *standard expression* for profits retained after payment of tax:

$$R - C - T = (1 - A/100)(R - C) + ABR/10^4 \quad (3)$$

This expression shows that after paying tax, the mine retains (1 - A/100) of its profit plus a fraction (AB/10⁴) of its gross revenue. This expression has been simplified by ignoring capital allowances, however, the results are essentially the same.

From (0) it can be seen that the states share of profits will be zero when X = B. This indicates the maximum ratio of profit to revenue the mine can earn before becoming liable to pay tax. The constant A gives the upper bound on the State's share of profits if the mine has a very high profit rate, i.e. for A = 60, the state can tax at a maximum of 60 percent (before any surcharges).

The *standard expression* makes quite clear the incentive a mine has to spend more than R100 in order to mine ore worth exactly R100. The sliding scale makes it possible for the mine to save more on tax payments than it loses by mining in an inefficient way.

A numerical example:

Assume a mine with A = 60 and B = 8 (i.e. a "480-formula" mine), the formula is then:

$$Y = 60 - 480/X$$

The standard expression then shows that the mine will retain

$$(1 - 60/100)(R - C) + 60 \times 8 \times R/10^4$$

$$= 0.4(R - C) + 0.048R \quad (4)$$

as profits.

Assume the mine spends (100 + Z) in order to earn 100, in order to find the maximum size of Z which does not reduce retained income, substitute 100 for R and (100 + Z) for C in (4) and set equal to zero, so that the reduction in the first term is exactly offset by the increase in the second.

The result is that

$$Z = 4.8/0.4$$

$$= 12$$

i.e. the mine can spend R112 to mine ore worth R100, without reducing its retained profits. The mine thus mines a lower *average* ore grade as it mines lower grade ore to reduce the pre-tax profits it makes on higher grade ore. This distortion of 12%, would be worsened by the imposition of any surcharge. In 1988, when the tax formula was imposed on top of the lease formula, and a surcharge of 25% was levied on top of everything, the distortion was as high as 38% in the case of some "480-formula" mines. That is the mines could spend R138 in order to mine ore worth R100 without reducing their retained (after tax) profits.

The following table shows the profitability of working various grades of ore for a mine facing the "480-formula" tax. Column (5) shows the retained profit at various grades, column (4) shows what the fisc would get from or contribute towards the mining of various grades. Columns (1) to (3) are the cost, additional revenue, and profit or loss made from mining various grades respectively. The grades are shown in descending order.

(1)	(2)	(3)	(4)	(5)
C	R	R - C	Tax	Retained
100	130	30	11.76	18.24
100	120	20	6.24	13.76
100	110	10	0.72	9.28
100	109	9	0.168	8.832
100	108	8	-0.384	8.384
100	105	5	-2.04	7.04
100	100	0	-4.8	4.8
100	95	-5	-7.56	2.56
100	90	-10	-10.32	0.32
100	85	-15	-13.08	-1.92
100	80	-20	-15.84	-4.16

The mine is thus encouraged to mine down to a grade of ore that is only between 85 and 90 percent of the grade that would be deemed payable in the absence of the tax (at an ore grade that yields R90 for every R100 spent, the mine adds R0.32 to its profits by reducing its tax payments by R10.32).

To illustrate the point, if a mine with the cost and grade structure in the above example mined one unit of ore worth R130, it would make an after tax profit of R18.24. If in addition it mined one unit of ore worth only R90 and thus reduced pre-tax profits to R20 it would increase after tax profits to R18.56 (up 32 cents), while the State's share from tax would fall from R11.76 to just R1.44 (down by R10.32).

In 1988, with the lease payments and the surcharge, the lowest profitable grade to mine went down to 72.61 percent of the grade that would have been mined in absence of the formula tax system, i.e. any mine with a tax burden of R27.39 could spend R100 to mine an extra unit of ore worth R72.61 without reducing their profits. The mines could thus waste R27.39, and reduce their tax burden by

the same amount. Thus, the fisc would pay the mines R27.39 (which it would have received if the ore had not been mined) to mine the ore. The fisc is thus R27.39 poorer, and the mines wasted R27.39 worth of resources, altogether a very expensive exercise.

As can be seen from the above table, it is obvious that the same effect could be attained by keeping the ore grade constant and changing the cost side of the equation. This could be done by mining to deeper levels or mining less accessible ore bodies. Thus the effect of the tax is not just on grade selection, but on mining technique as well. The tax gives the mines an incentive to raise costs (in order to lower the profit-revenue ratio and thus the tax burden), which is obviously an inefficient and undesirable result from society's perspective (as valuable resources are wasted), but a perfectly rational one from the mine manager's profit maximising perspective.

Appendix E

An outline of a control theory approach to analysing the influence of the formula tax on extraction and ore grade

The following is an initial outline of a control theory approach to the influence of the formula tax on extraction and ore grade. The problem follows the pattern of the problems presented in chapter two of this paper, and assumes that the owner of a mine wishes to maximise the current value of after tax profits. Two possible scenarios are presented, one where there is no tax and one with the formula tax. The effects of the tax on the time path of average ore grade is then compared to the case of no tax.

Let:

$G(t)$ = average grade of ore extracted in time t

$m(t)$ = the extraction rate, i.e. the amount extracted in each time period t

$P(t)$ = the price for the refined metal received in time period t

$M(t)$ = the amount of ore remaining in the ground in time period t

$C(M(t))$ = the cost of extraction in time period t as a function of M , $dC/dM < 0$

T = terminal time

1. In the case where no tax is levied, the maximisation problem facing the resource owner can be expressed as:

$$\begin{aligned} & \text{MAX}_m \int_0^T e^{-\delta t} [GmP - C(M)]dt \\ \text{s.t. } & m = -dM/dt \quad M(0) = M_0 \quad M(T) \geq 0 \quad T \text{ free} \end{aligned}$$

The current value Hamiltonian is then:

$$H = [GmP - C(M)] + \lambda(-m)$$

The first order conditions are:

$$\partial H / \partial m = GP - \lambda = 0 \quad (1)$$

$$\partial H / \partial M = -\dot{\lambda} = -C_M \quad (2)$$

$$\partial H / \partial \lambda = -m = dM/dt$$

$$\lambda(T) \geq 0 \quad M(T) \geq 0 \quad \lambda(T)M(T) = 0$$

$$(1) \ \& \ (2) \Rightarrow \quad \dot{\lambda} = \dot{G}P + \dot{P}G = C_M$$

$$\Rightarrow \quad \dot{G} = (C_M - \dot{P}G)/P \quad \text{or} \quad \dot{G}P = C_M - \dot{P}G \quad (3)$$

I.e. the value of a change in average grade must equal the marginal cost of extraction less the change in value of the average grade mined due to the change in price.

2. In the case of a mine facing the formula tax, the maximisation problem faced by the owner can be expressed as:

$$\begin{aligned} \text{MAX}_m \int_0^T e^{-\delta t} [(1-A)(GmP - C(M)) + ABGmP] dt \\ \text{s.t. } m = -dM/dt \quad M(0) = M_0 \quad M(T) \geq 0 \quad T \text{ free} \end{aligned}$$

where A and B are both constants greater than zero and less than one.

The current value Hamiltonian is then:

$$H = [(1-A)(GmP - C(M)) + ABGmP] + \lambda(-m)$$

The first order conditions are:

$$\partial H / \partial m = (1-A)GP + ABGP - \lambda = 0 \quad (4)$$

$$\partial H / \partial M = -\dot{\lambda} = -(1-A)C_M \quad (5)$$

$$\partial H / \partial \lambda = -m = dM/dt$$

$$\lambda(T) \geq 0 \quad M(T) \geq 0 \quad \lambda(T)M(T) = 0$$

$$(4) \ \& \ (5) \Rightarrow \quad (1-A+AB)(\dot{G}P + \dot{P}G) = (1-A)C_M$$

$$\begin{aligned}
0 < AB < A &\Rightarrow (1-A+AB) > (1-A) \\
&\therefore (1-A+AB)/(1-A) > 1 \\
\text{let } &(1-A+AB)/(1-A) = Z
\end{aligned}$$

then:

$$\begin{aligned}
Z(\dot{G}P + \dot{P}G) &= C_M \\
\Rightarrow \dot{G} &= (C_M - Z\dot{P}G)/ZP \quad (6)
\end{aligned}$$

I.e. the tax augmented value of a change in average grade must equal the marginal cost of extraction less the tax augmented change in value of average grade due to a change in price.

Let \dot{G} in the tax case be referred to as \dot{G}_t .

3. Now assuming $\dot{P}G$ and C_M identical for both cases³⁷, \dot{G}_t can be compared to \dot{G} .

Assuming $\dot{P} > 0$ (as per Hotelling's assumption)

$$\begin{aligned}
\text{Since } Z > 1 &\Rightarrow C_M - Z\dot{P}G < C_M - \dot{P}G \\
&\text{and } ZP > P \\
&\therefore \dot{G}_t < \dot{G}
\end{aligned}$$

Three cases are now possible:

$$\begin{aligned}
\text{(i)} \quad \dot{P}G &< C_M \\
Z\dot{P}G < C_M &\Rightarrow 0 < \dot{G}_t < \dot{G}
\end{aligned}$$

I.e. the change in value of the average ore grade due to the change in price is less than the change in cost of extraction for both cases.

$$\begin{aligned}
\text{(ii)} \quad \dot{P}G &< C_M \\
Z\dot{P}G > C_M &\Rightarrow \dot{G}_t < 0 < \dot{G}
\end{aligned}$$

³⁷ This unfortunately introduces a static element to the dynamic problem, as such the results that follow are not technically acceptable. It does, however, allow the analysis to proceed in order to give some indication of the kind of effect the formula tax has on the average grade path as compared to the case where no tax is charged.

I.e. the change in value of the average ore grade due to the change in price is less than the change in cost of extraction for the no tax case, but greater than change in cost in the tax case.

$$(iii) \quad P \dot{G} > C_M$$

$$Z \dot{P} G > C_M \Rightarrow \dot{G}_t < G < 0$$

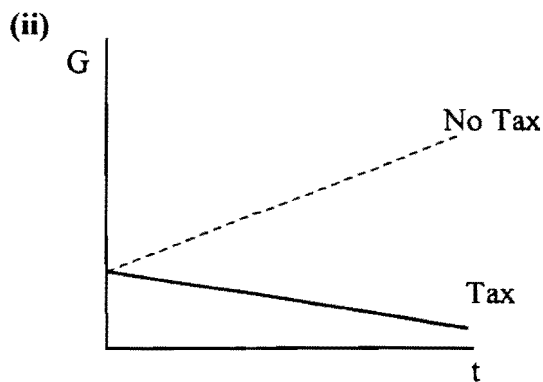
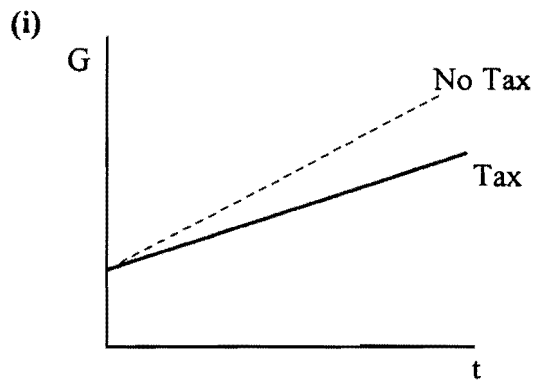
I.e. the change in value of the average ore grade due to the change in price is greater than the change in cost of extraction for both cases.

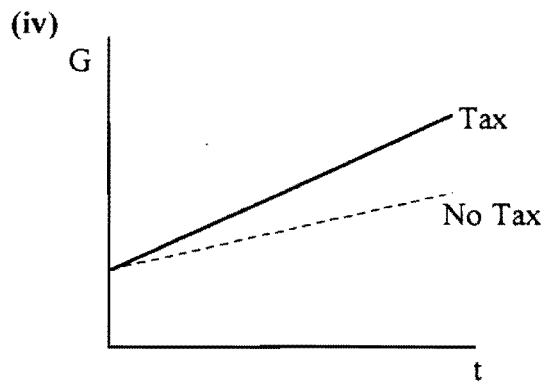
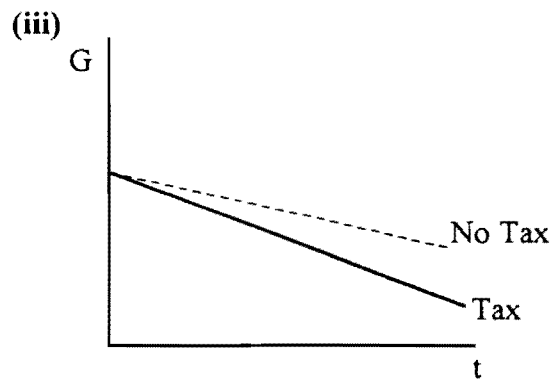
If \dot{P} is assumed to be negative a fourth case is possible:

$$(iv) \quad \dot{G} > 0$$

$$\dot{G}_t > 0 \text{ and } \dot{G}_t > G \Rightarrow 0 < \dot{G} < \dot{G}_t$$

The four cases are plotted below with G assumed equal to zero for convenience.





Bibliography

ANC Minerals and Energy Policy Workshop : "Draft Mineral and Energy Policy Discussion Document", November 1994

A.N.C. : A.N.C. Policy Guidelines, F. The Environment

Beckerman W. : Pricing for Pollution 2nd ed.
Hobart Paper 66, I.E.A., 1990

Blaug M. : Economic Theory in Retrospect, 4th ed.
Cambridge University Press, 1985

Boadway R., Bruce N., McKenzie K. and Mintz J. : "Marginal Effective Tax Rates for Capital in the Canadian Mining Industry"
Canadian Journal of Economics, February 1987, pp. 1-16

Bhorat H. & Cassim R. : "South Africa's Mineral Commodity Sector: A Strategy for Industrialisation"
Trade Monitor, June 1995, vol. 9 pp. 11-15

Busschau W.J. : The Theory of Gold Supply with Special Reference to the Problems of the Witwatersrand
Oxford University Press, 1936

Campbell H.F. and Lindner R.K. : "A Model of Mineral Exploration and Resource Taxation"
The Economic Journal, March 1985 pp. 146-160

Conrad J.M. and Clark C.W. : Natural Resource Economics, Notes and Problems
Cambridge University Press, 1991

Conrad R.F. and Hool B. : “Resource Taxation with Heterogeneous Quality and Endogenous Reserves”

Journal of Public Economics, vol. 16 pp. 17-33 1981

Dasgupta P.S. and Heal G.M. : Economic Theory and Exhaustible Resources

Cambridge University Press, 1979

Daly H.E. : “Towards Some Operational Principles of Sustainable Development”

Ecological Economics, vol.2 1990

Dore M.H.I. : “Mineral Taxation in Jamaica: An Oligopoly Confronts Taxes on Resource Rents - and Prevails”

American Journal of Economics and Sociology, vol. 46 no 2 1987

Fisher A.C. : Resource and Environmental Economics

Cambridge University Press, 1981

Fulton M. and Just R.E. : “Antitrust, Exploration, and Social Optimality in Nonrenewable Resource Markets”

Journal of Environmental Economics and Management, vol. 17 pp.1-21 1989

Gamponia V. and Mendelsohn R. : “The Taxation of Exhaustible Resources”

The Quarterly Journal of Economics, February 1985

Gray L.C. : “Rent Under the Assumption of Exhaustibility”

Quarterly Journal of Economics, vol. 28 pp. 466-489 1914

Hartwick J.M. : “Intergenerational Equity and the Investing of Rents from Exhaustible Resources”

The American Economic Review, vol 67 no 5 pp. 972-974

Hartwick J.M. and Olewiler N.D. : The Economics of Natural Resource Use

Harper and Row, 1986

Haugom H. : A Model of South African Gold Production

Unpublished, 1991

Heaps T. : "The Taxation of Nonreplenishable Natural Resources Revisited"

Journal of Environmental Economics and Management, vol. 12 pp. 14-27 1985

Hotelling H. : "The Economics of Exhaustible Resources"

The Journal of Political Economy, vol.39 no.2 1931

Kaplan M. and Dale M.O. : A Guide to the Minerals Act 1991

Butterworths Publishers, 1992

Keynes J.M. : The General Theory of Employment, Interest, and Money

First Harbinger Edition 1964

Kolstad C.D. and Wolak F.A. Jr. : "Competition in Interregional Taxation: The Case of Western Coal"

Journal of Political Economy, vol.91 no.3 1983

Krautkraemer J.A. : "Taxation, Ore Quality Selection, and the Depletion of a Heterogeneous Deposit of a Nonrenewable Resource"

Journal of Environmental Economics and Management, vol. 18 pp. 120-135

1990

Kruger F.J. and de Wit M.J. : "Mineral Laws and Greater Equity in a Future South Africa"

International Affairs Bulletin, vol.11 no.2 1987

Livernois J.R. : "Marginal Effective Tax Rates for Capital in the Canadian Mining Industry: An Extension"

Canadian Journal of Economics, February 1989, pp.184-194

Livernois J. : "A Note on the Effects of Tax Brackets on Non-renewable Resource Extraction"
Journal of Environmental Economics and Management, vol. 22 pp. 272-280
1992

Maas W.F. : "Profitability of South Africa's Gold Mines, and the Factors Influencing It"
Bulletin B18/89 (Johannesburg: Minerals Bureau, 1989)

Moll T. : "Accounting for Gold: The South African Case"
Review of Income and Wealth, Series 38, no. 2 June 1992

Nattrass N. : "The Crisis in South African Gold Mining"
World Development, vol. 23 no. 5 pp. 857-868

Rees D. : "Tax and the Gold Mining Industry"
Unpublished Discussion Paper, UCT

Rees J. : Natural Resources Allocation, Economics and Policy
Methuen & Co. Ltd., 1985

Report of the Commission of Inquiry into the Tax Structure of the Republic of South Africa
RP34/1987, Government Printer

Ryan B. : "SA Lags, Not Leads"
Finance Week, March 30-April 5 1995

Slade M.E. : "Tax Policy and the Supply of Exhaustible Resources: Theory and Practice"
Land Economics, vol. 60 no. 2 1984

Slade M.E. : "Taxation of Non-renewable Resources at Various Stages of Production"
Canadian Journal of Economics, vol. 19 no.2 1986

Solomon M. : "Fiscal and Financial Governance of the Mining Industry"

Draft for inclusion in a Minerals and Energy Policy
reader, 1994

Stollery K.R. : "Mineral Processing in an Open Economy"

Land Economics, vol.63 no.2 1987

Swierzbinski J.E. and Mendelsohn R. : "Information and Exhaustible Reserves: a Bayesian
Analysis"

Journal of Environmental Economics and Management, vol. 16 pp. 193-208
1989

Tausig F.W. : Principles of Economics, volume II second edition revised

The Macmillan Company, 1920

Taylor J. : "The Challenge of Sustainable Development"

Regulation, 1994 no.1 pp. 35-50

Urquart M. : "Higher Grade Policy Lifts Randgold's Production"

Business Day, 25/7/95

World Resources 1992-93, A Report by the World Resources Institute

in collaboration with

The United Nations Environmental Programme

and

The United Nations Development Programme

Oxford University Press, 1992