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EUROPEAN ATOMIC ENERGY COMMUNITY - EURATOM

THE OPTIMIZATION OF MINERAL EXPLORATION INVESTMENTS BY THE COMPUTER PROGRAM "EXILE"

by

H.I. DE WOLDE and J.W. BRINCK

1969

Joint Nuclear Research Center
Ispra Establishment - Italy

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ABSTRACT

This report describes a method and a computer program for optimizing mineral exploration investments by the following standards :

1. An adequate capitalized reserve, in relation to future annual requirements, must always be accessible.
2. Schock effects must be avoided ; strong variations must be levelled out smoothly.
3. Expenditures have to be minimal with respect to the first two conditions.

Minimal annual discovery rates are calculated together with investment schemes, exploration areas and exploration costs per km^2.
Sequential alternatives (levelled) are proposed.
The combined results may be obtained in graphical form also.

KEYWORDS

ORES
PROGRAMMING
ECONOMICS
DEPOSITS
COST
E-CODES

CONTENTS

THE OPTIMIZATION OF MINERAL EXPLORATION INVESTMENTS BY THE COMPUTER PROGRAM "EXILE"*)

INTRODUCTION

The search for an exploitable mineral deposit and the developing of a deposit into the production stage, takes a number of years and requires relatively large investments. This report describes a method by which investment policies may be optimized, satisfying the conditions:

1. A sufficient capitalized reserve, expressed as a multiple of the annual needs, has to be always accessible.
2. Shock effects due to sudden variations in consumption patterns have to be leveled.
3. With respect to the first two conditions, the investments must be kept as low as possible.

The calculation method has been used to develop a computer program called "EXILE", (EXploration Investment LEveling), which calculates first the minimal necessary discovery rate, based on the expected annual requirements. Sequentially the minimal investments and the exploration areas are calculated together with the allowed exploration price per km^2. Additional calculations deliver leveled investment policies respecting the minimal conditions.

All the results may be delivered in graphical form for easy interpretation.

The program does not take into account the costs of the actual capitalizations; only exploration costs and exploration investments, including interest, are considered.

An outline of the main items will be given first.
Consider the schematic history of a productive mine. During a certain number of years, i_e, a certain area of S km^2 has been explored until the exploitable deposit was discovered. During a second period of minimal i_p years, the deposit has been equipped with technical installations, roads, etc. This second period may have been extended to i'_p years if the need for accessible mineral was not urgent. After $i_e + i'_p$ years a productive mine exists with, for example, a total reserve of V tons of metal. At this moment the deposit is defined as being capitalized.

*) Manuscript received on 10 September 1969.

A table of the minimal annual discoveries may be calculated, if the annual requirements of the metal are given, under the assumptions:

1. The capitalized reserves must be a multiple, c, of the annual requirements.
2. The not capitalized reserves have to be as small as possible.
3. The time delays for discovery, i_e, and capitalization, i_p, have to be taken into account.
4. The discovery rate may not decrease below a defined level.

In another stage of the calculations the annual discovery rates may be leveled, provided that the execution of the minimum program is possible at any moment.

The exploration areas may be calculated out of the total world reserves. If, for example, an annual discovery rate has been estimated as V tons of metal, the corresponding exploration area may be calculated as:

$$S = \frac{V}{R} \times 1.5 \times 10^8 \ km^2 \qquad (1)$$

in which R are the total known world reserves and 1.5×10^8 is the earth's dry land surface.

A more sophisticated method to calculate the exploration areas is given by the theory of one of the authors on the predictability of minerals in the earth's crust. By means of this concept one may calculate the probability of occurrence of any size deposit of any grade. The program "EXILE" contains an option for applying this theory. This is especially important if one may expect that in future lower grade deposits will become exploitable. A short description of the theory on the predictability of minerals is given in Appendix A.

Once a deposit has been capitalized, the ore has a certain market value of, for example, Q $/ton metal. The total costs of the exploration including interests, C, may amount to a fraction, a, of the value or, if the deposit contains V tons of metal:

$$C = a \cdot Q \cdot V \ \$ \qquad (2)$$

During the first i_e years the exploration is financed by annual equal amounts and during the sequential period of i'_p years, until the capitalization, only interests are considered. The expressions for net investments, gross investments, etc. will be derived.

The complete calculations are first performed as a minimum program i.c. the predisposed conditions are minimal respected. In a sequential recalculation the discovery rates are leveled in such a way that the minimum program can be executed always, but strong variations are avoided. The total costs of a leveled program remain the same as for the not leveled minimum program. The extra costs of the sometimes larger reserves are corrected by a lower net investment per ton of metal.

Although the program EXILE has been designed for the uranium exploration, it may also be used for other mineral investment calculations.

THE ANNUAL STOCKTABLE

Consider a future period of N years for which the annual metal requirements are known:

$$D_1, D_2, \ldots, D_i, \ldots, D_N \text{ tons of metal per year} \tag{3}$$

Defining the time for a successful exploration as i_e years and the necessary time for capitalization as i_p years, then the exploration investment policy has to be planned at least $i_e + i_p$ years in advance: the start of an exploration in the year i is related to the annual requirement in the year $i + i_e + i_p$.

The accumulative reserves are defined:

$$M_o, M_1, \ldots, M_i, \ldots, M_N \text{ tons of metal, capitalized reserve} \tag{4}$$

$$M'_o, M'_1, \ldots, M'_i, \ldots, M'_N \text{ tons of metal, not capitalized reserve} \tag{5}$$

in which M_o and M'_o are the reserves at the beginning of the period in consideration and M_i and M'_i are the cumulative reserves at the end of year i.

The annual discovery rate is:

$$M''_1, M''_2, \ldots, M''_i, \ldots, M''_N \text{ tons of metal per year} \qquad (6)$$

with an eventual minimum of M''_{MIN} tons of metal per year.

In the next pages i is always the floating index for the years of the considered period; $1 \leq i \leq N$. The average time for a successful exploration is i_e years and the time between the discovery of a deposit and its capitalization is i'_p years with a minimum of i_p years: in the non-leveled calculations it is assumed that a deposit is normally capitalized i_p years after the discovery in contradiction to the leveled calculations where the capitalization is performed according to the requirements.

The annual stocktable may now be calculated based on the assumptions:

1. The capitalized reserves must be a plural of the annual requirements:

$$M_i = c \cdot D_i \qquad (7)$$

2. The non-capitalized reserves have to be as small as possible i.c. just enough to supply the annual capitalized quantity for the first i_p years
3. The discovery rate M''_i will be at least M''_{MIN} tons/year.
4. The initial reserves M_o and M'_o must be corrected as soon as possible if they do not satisfy items 1. and 2.

The actual relations become:

$$\begin{cases} M_i = M_{i-1} - D_i & \text{if } M_{i-1} - D_i \geq c.D_i \qquad (8) \\ M_i = c.D_i & \text{if } M_{i-1} - D_i < c.D_i \qquad (9) \end{cases}$$

$$V_i = M_i - M_{i-1} + D_i \qquad (10)$$

in which V_i is the annual capitalized quantity.
The condition for the non-capitalized reserves is:

$$M'_i \geq \sum_{j=i+1}^{i+i_p} V_j \qquad (11)$$

Thus M'_i and M''_i may be calculated:

$$\left.\begin{array}{l} M'_i = M''_{i-1} - V_i + M''_{MIN} \\ M''_i = M''_{MIN} \end{array}\right\} \text{ if } M'_{i-1} - V_i \geq \sum_{j=i+1}^{i+i_p} V_j \qquad (12)$$

or:

$$\left.\begin{array}{l} M'_i = \sum_{j=i+1}^{i+i_p} V_j \\ M''_i = M'_i - M'_{i-1} + V_i \end{array}\right\} \text{ if } M'_{i-1} - V_i < \sum_{j=i+1}^{i+i_p} V_j \qquad (13)$$

In order to calculate the stocktable until the year N, the annual requirements D_i, past the year N must also be known.
Program EXILE averages the annual requirements over the last three years of the considered period and defines:

$$D_i = [D_N + D_{N-1} + D_{N-2}]/3 \quad i = N+1, \ldots, N+i_p \qquad (14)$$

With the relations (7) to (14) the table of the annual material balances may be composed. The calculated discovery rate, M''_i, is a minimum quantity. In another stage of the program certain variations will be introduced by which the discovery rate will be increased sometimes, to avoid unrealistic peaks in its appearance.

THE EXPLORATION INVESTMENTS

In the previous paragraph the expressions for the annual capitalization V_i, and the discovery rate, M''_i, have been derived. In order to calculate the gross investment on V_i, the number of years between discovery and capitalization and the period before discovery must be known.
It is assumed that during the exploration period of i_e years, each year an equal amount, B_i $ on M''_i tons of metal has been invested. So the gross investment increases during the first i_e years as follows:

year:	cumulative investment:
1.	$W_{i1} = B_i \left[1 + k\right]$
2.	$W_{i2} = B_i \left[1 + k\right] + B_i \left[1 + k\right]^2$
- - - -	- - - - - - - - - - - - - - - - - -
i_e.	$W_{ii_e} = B_i \sum_{j=1}^{i_e} \left[1 + k\right]^j$ (15)

in which k is the interest rate.
On the moment of discovery of M_i'' the value is estimated as W_{ii_e}. Afterwards the investments increase only with the interests until the year of capitalization i_p' with $i_p' \geqslant i_p$:

$$C_{M_i''} = \left[1 + k\right]^{i_p'} \cdot B_i \cdot \sum_{l=1}^{i_e} \left[1 + k\right]^l \qquad (16)$$

in which i_p' is counted from the year of discovery.
However, it may happen that not the whole quantity M_i'' will be capitalized in the same year: M_i'' might be capitalized fractionally. A capitalization scheme may now be calculated based on the principle of "first in, first out".
A numerical example of such a scheme is given:

year →			1	2	3	4	5
↓	V_i	v_{io}					
1	0	0	0	0	0	0	0
2	190	190	0	0	0	0	0
3	9920	9920	0	0	0	0	0
4	11210	11210	0	0	0	0	0
5	11010	11010	0	0	0	0	0
6	12720	2670	4500	4500	1050	0	0
7	13910	0	0	0	3450	10460	0
8	15190	0	0	0	0	0	15190
		M_o'=35000	4500	4500	4500	10460	15190
			M_i'' →				

In the aforegoing table V_i is the annual capitalization; v_{io} represents the digestion of the initial not capitalized reserves M'_o and the last part of the matrix shows the flow of material from the annual discovery rate to the annual capitalization: v_{ij} represents tons of metal, discovered in the year j and capitalized in the year i.

The matrix v_{ij} may be developed by columns according to:

$$\begin{cases} v_{io} = V_i & \text{if } M'_o - \sum_{l=1}^{i-1} v_{lo} \geq V_i \\ v_{io} = M'_o - \sum_{l=1}^{i-1} v_{lo} & \text{if } M'_o - \sum_{l=1}^{i-1} v_{lo} < V_i \end{cases} \tag{17}$$

$$\begin{cases} v_{ij} = V_i - \sum_{l=0}^{j-1} v_{il} & \text{if } M''_j - \sum_{l=1}^{i} v_{lj} \geq 0 \\ v_{ij} = M''_j - \sum_{l=1}^{i-1} v_{lj} & \text{if } M''_j - \sum_{l=1}^{i} v_{lj} < 0 \end{cases} \tag{18}$$

This rather complicated representation is necessary for the performing of the leveling of the discovery rate, which will be explained in one of the following paragraphs.

Once a deposit has been capitalized, the ore has an intrinsical value of Q \$/ton of metal. The total costs of the exploration including interests may amount to a fraction, a, of the value:

$$C_i = a \,.\, Q \,.\, V_i \ \$ \tag{19}$$

Taking together the expressions (16), (19) and the capitalization scheme the annual net investments B_j may be calculated:

$$\sum_{i=1}^{N} \frac{v_{ij} \times a \times Q}{[1 + k]^{i-j}} = B_j \times \sum_{l=1}^{i_e} [1 + k]^l \tag{20}$$

or:
$$B_j = \frac{1}{\sum_{l=1}^{i_e} [1 + k]^l} \times \sum_{i=1}^{N} \frac{v_{ij} \times a \times Q}{[1 + k]^{i-j}} \tag{21}$$

Each year, during a period of i_e years, an amount of B_j \$ may be invested, for the discovery of M''_j tons of metal, after i_e years.

With the previous expressions one may calculate the investments at time zero, which are of two different types:

1. Investments in relation to the non-capitalized reserves at time zero: M'_o
2. Investments performed before the year zero which will yield the annual discoveries in the years 1, 2, ..., i_e-1.

The gross investment on M'_o at capitalization time is:

$$C_{M'_o} = a \times Q \times M'_o \ \$ \qquad (22)$$

in which a is again the exploration fraction on the capitalized product price of Q \$/ton of metal.
Reduced to the time zero the investment on M'_o is:

$$I'_{M'_o} = a \times Q \times \sum_{i=1}^{N} \frac{v_{io}}{[1 + k]^i} \qquad (23)$$

Furthermore investments have been made before time zero on the discoveries in the first i_e-1 years. As has been mentioned already, it is assumed that the net investments for a certain annual discovery are divided in i_e annual equal parts, B.
Thus the net investment on M''_1 at time zero has already accumulated to:

$$[i_e - 1] \times B_1 \ \$ \qquad (24)$$

and the gross investment on M''_1 is:

$$B_1 \times \sum_{l=1}^{i_e-1} [1 + k]^l \ \$ \qquad (25)$$

The total investments before time zero on the discoveries in the first i_e - 1 years are:

$$I'_{M''_i} = \sum_{n=1}^{i_e-1} B_n \sum_{l=1}^{i_e-n} [1 + k]^l \qquad (26)$$

Combining the expressions (23) and (26) together, the gross investment at time zero is:

$$I'_o = a \times Q \times \sum_{i=1}^{N} \frac{v_{io}}{[1 + k]^i} + \sum_{n=1}^{i_e - 1} B_n \sum_{l=1}^{i_e - n} [1 + k]^l \qquad (27)$$

Some other relations are also calculated:

The total net investment in the year i is:

$$I_i = \sum_{j=i}^{i+i_e-1} B_j \qquad (28)$$

The annual gross proceeds are:

$$C_i = a \times Q \times V_i \qquad (29)$$

The cumulative investments are:

$$\hat{I}_i = [\hat{I}_{i-1} + I_i] \times [1 + k] - C_i \qquad (30)$$

The new investments are defined as:

$$I'_i = I_i - D_{i-1} \times a \times Q \qquad (31)$$

The net investment per ton of metal on M''_i is:

$$J = \frac{i_e \times B_i}{M''_o} \qquad (32)$$

THE EXPLORATION AREAS

Once the discovery rates and the investments have been calculated, the question of the areas to be surveyed to find the necessary target deposits, remains to be solved.

An exploitable deposit is defined as being such, not only by its grade but also by its size, i.e. the total available quantity of tons of metal must increase if the grade is lower.

Furthermore, if the price of a raw material increases, also lower grade deposits may become exploitable. Due to new technological developments, at present

not exploitable deposits, might become exploitable in future.
Under these circumstances it is difficult to give a reasonable calculation of exploration areas. The figures as delivered by the EXILE method need experienced interpretations but as trend indicators they have proved to be useful.

The EXILE method supplies two ways of calculating the exploration areas. The first is simply based on the average presently exploited deposit. As the target deposit is taken the average deposit with average grade.
If the total world reserves are R tons of metal and the average ore deposit contains r tons of metal, then the number of occurring deposits may be approximated by:

$$m = \frac{R}{r} \tag{33}$$

The specific area per exploitable deposit is:

$$S = \frac{1.5 \times 10^8}{m} \text{ km}^2 \tag{34}$$

The discovery of a new deposit takes an average of i_e years, thus the exploration to start in the year i must cover an area of:

$$S_i = \frac{M''_{i+i_e}}{r} \times S \text{ km}^2 \tag{35}$$

The second method of calculating the exploration areas is based on the theory of one of the authors concerning the predictability of minerals in the earth's crust. By means of this concept one may calculate the probability of occurrence of any size of deposit of whatever grade. This is especially important if one may expect that in future lower grade deposits will become exploitable. A short description of the theory on the predictability of minerals is given in Appendix A. Concerning the application of this theory in the EXILE program; for each year of the considered period one may specify the size and the grade of the target deposit.

Suppose the absolute dispersion coefficient α has been calculated based on the average exploitable deposit and the total world reserves, as described in Appendix A. The target deposit for a certain time is defined as Z tons of metal in an ore of X_K ppm.

The volume of the target deposit is:

$$V = \frac{Z}{X_K} \times 10^6 \times \frac{1}{\rho} \times 10^{-9} \text{ km}^3 \tag{36}$$

in which ρ is the specific gravity of the ore.
The linear equivalent may be calculated according to:

$$a = \sqrt[3]{\frac{V}{[b/a]^2 \times c/b}} \text{ km} \tag{37}$$

$$d = a \times [1 + b/a + b/a \times c/b] \text{ km} \tag{38}$$

The median grade for samples with an average size Z is:

$$\gamma_R = \frac{\overline{X}}{\exp[\,0.015 \times \alpha \times \log \frac{D}{d}]} \tag{39}$$

The standard deviation is then given by:

$$\sigma = \sqrt{2 \log \frac{\overline{X}}{\gamma_R}} \tag{40}$$

The probability of occurrence:

$$P = 0.5 \times \left[1 - \text{erf}\left[\frac{\log X_K - \log \gamma_R}{\sqrt{2}\,\sigma}\right]\right] \tag{41}$$

The number of deposits $[Z,X_K]$ for whole the earth's crust:

$$m = \frac{P \times R}{Z} \tag{42}$$

in which R is the total quantity of tons of the earth's crust. The specific area per deposit $[Z,X_K]$ is thus:

$$S = \frac{1.5 \times 10^8}{m} \text{ km}^2 \tag{43}$$

If now the exploration area has to be calculated based on a target deposit $[Z,X_K]$, the surface to be explored in the year i is:

$$S_i = \frac{M''_{i+i_e}}{Z} \times S \text{ km}^2 \tag{44}$$

The allowed exploration price per km^2 in the year i is:

$$T_i = \frac{I_i}{S_i} \; \$/km^2 \tag{45}$$

in which I_i is the total net investment according to expression (28).

The unit exploration cost per ton of metal is the empirical cost of finding one ton of metal contained in ore deposits of current average grade and size. If in future lower grade deposits of larger size become exploitable, the unit exploration cost will depend essentially on the probability of finding such deposits. This probability is directly proportional to the probable number of target deposits available in the geological environment and the size of the deposits expressed as linear equivalents. The unit exploration cost is inversely proportional to the grade of the ore. Thus if the future unit cost is expressed in ratio to the present one:

$$U_i = \frac{X_1 \times d_1 \times m_1}{X_i \times d_i \times m_i} \times a \times Q \quad \$/\text{ton of metal}$$

in which: U_i = unit exploration cost per ton of metal
d_i = the linear equivalent in km
m_i = the probable number of deposits of grade X_i and size d_i (see expression (42)).

THE LEVELING OF THE ANNUAL DISCOVERY RATE

The annual discovery rates as calculated by the expressions (12) and (13) are minimum quantities. They may show a rather jumpy curve which is of course not a very practical policy to follow. Thus a certain leveling must be performed in such a way that the minimum program can always be executed. That means that for each year i the sum of the discovery rates from zero to i of the leveled curve must be larger than or equal to the same for the not leveled case:

$$\int_o^i \overline{M}''_i \, d_i \geq \int_o^i M''_i \, d_i \qquad \text{for all i} \tag{46}$$

in which $\overline{M}''_i$ are the leveled annual discovery rates and M''_i are the minimum annual discovery rates according to the previously described relations.

The discovery rates during the first i_e-1 years cannot be changed because they are already planned before the start of the considered period. These figures are used for estimating a left boundary and a preference direction for the forward leveling. Applying the method of the linear least squares on the first i_e-1 points, the coefficients a and b must be solved:

$$\overline{M}'' = a.i + b \qquad (47)$$

Then:

$$a = \frac{2 \sum_{l=1}^{i_e-1} \left[2l-i_e\right].\left[M''_l - M''_{av}\right]}{\sum_{l=1}^{i_e-1} \left[2l-i_e\right]^2} \qquad (48)$$

in which: $$M''_{av} = \frac{1}{i_e-1} \sum_{j=1}^{i_e-1} M''_j \qquad (49)$$

and: $$b = \frac{\sum_{j=1}^{i_e-1} M''_j}{i_e-1} - a \times 0.5 \times i_e \qquad (50)$$

However, normally the integral of the linear least square curve is not the same as the integral of the actual curve so a correction c has to be added:

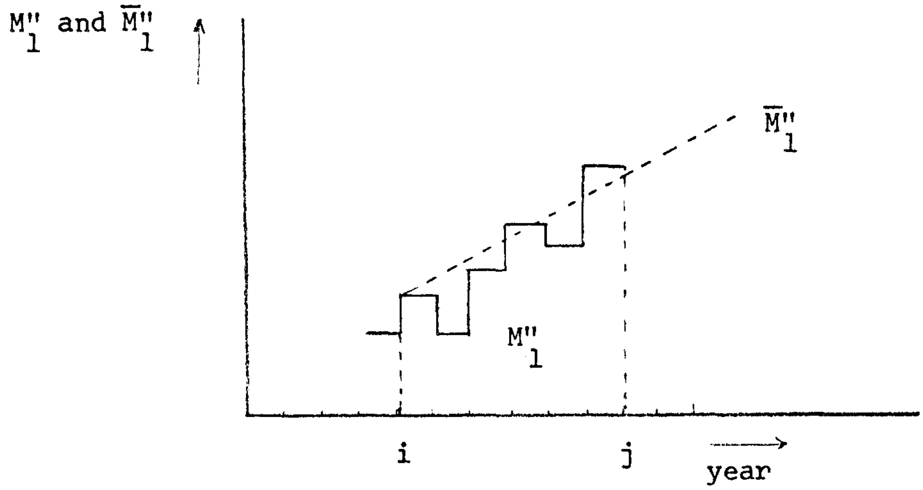
$$\sum_{j=1}^{i_e-1} \left[a.j + b + c\right] = \sum_{j=1}^{i_e-1} M''_j \qquad (51)$$

or:

$$c = \frac{1}{i_e-1} \times \left[\sum_{j=1}^{i_e-1} M''_j - aj - b \right] \qquad (52)$$

The point with the coordinates (i_e-1) and (a(i_e-1) + b + c) is the starting point for the forward leveling. The direction coefficient a is normally used as a preference direction, but EXILE contains also an option for specifying a preference direction independently, which may lead to alternative leveling procedures.

Assume a point i,$\overline{M}''_i$ until which the leveling has been performed and consider an interval [i+1, j] as shown in the next figure:



The interval i+1, j may be leveled by a linear relation:

$$M'' = a.x + b \qquad \text{in which } x = i+1,\ i+2,\ \ldots,\ j$$

The coefficients a and b are solved by the conditions:

1. $$\int_i^j \overline{M}''\,dx = \int_i^j M''\,dx \qquad (53)$$

2. $i, \overline{M}''_i$ is a known point of the function $\overline{M}''$ (54)

In numerical notation:

1. $$\sum_{l=i+1}^{j} \left[a.l + b\right] = \sum_{l=i+1}^{j} M''_l \qquad (55)$$

2. $$\overline{M}''_i = a.i + b \qquad (56)$$

Thus:

$$a \sum_{l=i+1}^{j} l + b[j-i] = \sum_{l=i+1}^{j} M''_l \qquad (57)$$

$$a \sum_{l=i+1}^{j} l + \left[\overline{M}''_i - ai\right] \times \left[j-i\right] = \sum_{l=i+1}^{j} M''_l \qquad (58)$$

$$a = \frac{\sum_{l=i+1}^{j} M''_l - \overline{M}''_i\,[j-i]}{\sum_{l=i+1}^{j} l - i[j-i]} \qquad (59)$$

$$b = \overline{M}''_i - ai \qquad (60)$$

However, the leveled discovery rate $\overline{M}''_l$ $l = i, i+1, \ldots, j$ has to be at any moment big enough to cover the minimum discovery rate M''_l thus:

$$\int_i^l \overline{M}'' \, dx \geq \int_i^l M'' \, dx \qquad \text{for } l = i+1, i+2, \ldots, j \qquad (61)$$

$$\text{or: } \sum_{n=i+1}^{l} \overline{M}''_n \geq \sum_{n=i+1}^{l} M''_n \qquad \text{for all } l = i+1, i+2, \ldots, j \qquad (62)$$

This condition is satisfied if the leveling according to (53) - (60) is performed for $l = i+1, \ldots, j$ and

$$a_l \leq a_j \qquad \text{for } l = i+1, i+2, \ldots, j-1 \qquad (63)$$

The actual leveling is now performed as follows: suppose the considered period contains N years and until the year i the discovery rates have been leveled already. The next intervals are leveled according to the previous expression and give thus rise to sets of coefficients a and b :

$$[i, i+1] \rightarrow a_{i+1}, b_{i+1}$$

$$[i, i+2] \rightarrow a_{i+2}, b_{i+2}$$

- - - - - - - - - - - - - - - - - -

$$[i, N] \rightarrow a_N, b_N \qquad (64)$$

However, only levelings respecting the condition (63) might be useful, thus the set of possible solutions is reduced to a set for which:

$$a_j \geq a_l \qquad \text{if } j > l \qquad (65)$$

Out of this reduced set the continuation of the leveling is chosen by the standard that the angle between the continued leveling and the leveling over the previous interval has to be as small as possible:

$$|\text{arctg } a_j - \text{arctg } a| = \text{minimal} \qquad (66)$$

in which a is the direction coefficient of the previous interval. Sequentially, the leveled annual discovery rate over the optimal interval may be calculated according to (56).

This procedure may be repeated until the whole period of N years has been leveled.

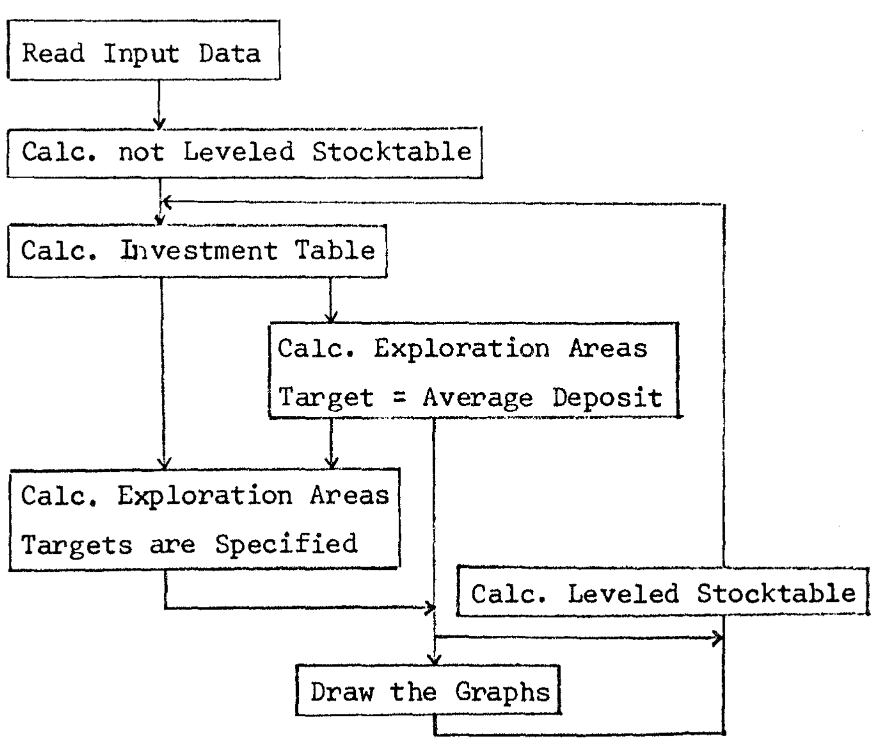
Once the leveling of the annual discovery rates M''_i has been performed the cumulative non-capitalized reserves must be corrected:

$$M'_i = M'_{i-1} - V_i + \overline{M}''_i \qquad (67)$$

in which V_i is the annual capitalized quantity as calculated according to the expression (10). Afterwards the whole calculation on the exploration investments and the survey areas can be repeated.

THE COMPUTER PROGRAM EXILE

The computer program EXILE follows the calculations as specified previously. The chapters are related as follows:



First the input data are read and printed. If a certain calculation of the absolute dispersion coefficient and the median content is requested, i.e. when the target deposits are specified for the exploration areas, the program prints these constants together with the input data. Sequentially, the annual material balances based on the minimal discovery rates are calculated and printed, followed by the investment tables. The two methods of exploration areas calculation are optional as is the graphical output. After the computation of the leveled stocktable, the second part of the program may be repeated.

The actual input for the EXILE program consists of a collection of fixed point and floating point numbers. A fixed point number is written without a decimal point, utmost right in its field. For EXILE all the fixed point fields are 6 columns. Floating point data are written with a decimal point and are eventually supplied with a fixed point exponent of 10. The position of such a number in its field is irrelevant, only the exponent must be placed at the utmost right. For all the floating point numbers in the EXILE input, the fieldwidth is defined as 12 columns.

Some examples may illustrate the number types:

input notition												type	value
											3	fixed	3
									3			fixed	300
									2	0	0	fixed	200
				1	.	2	3	4				floating	1.234
							1	.	2	3	4	floating	1.234
			2	.	1				E	+	3	floating	$2.1x10^3$
			2	.	1				E	-	3	floating	0.0021
								3	E	+	1	erroneous	
						3	.	E	+	1	.	erroneous	

The next list gives a detailed description of the input. The items and the symbols refer to the input sheet and the formulas as developed before. Also the internal Fortran names are specified.

ITEM	CARDS	SYMBOL	FORTRAN NAMES	RELATED EXPRESSIONS	
A	1	I_1	IND(1)		=0 no action
				35	=1 target deposit=average deposit
		I_2	IND(2)		not used
		I_3	IND(3)		=0 no action
				36-44	=1 target deposits are specified
		I_4	IND(4)		=0 no action
				56	=1 perform also the leveling
		I_5	IND(5)		=0 no action
					=1 graphical output required according to the next specifications
		K_i	IGRAPH (i)		maximal 10 requested graphs:
				3	=1 annual requirements
				12-13	=2 annual discovery rates
				12-13	=3 non capitalized reserves
				8-9	=4 capitalized reserves
				10	=5 annual capitalization
				28	=6 annual net investment
				29	=7 annual income
				30	=8 cumulative investment
				31	=9 new investments
				35	=10 exploration areas, according to I_1=1
					=11 exploration price $/km^2, according to I_1=1
				43-44	=12 exploration areas, according to I_3=1
					=13 exploration price, according to I_3=1
					=14 cumulative requirements
					=15 total reserves
B	1	r	RSMALL	33-35	tons of metal total exploitable world reserves
		Z	ZA		tons of metal average ore deposit
		X_r	XRSM		ppm average grade of the world reserves

ITEM	CARDS	SYMBOL	FORTRAN NAMES	RELATED EXPRESSIONS	
C	[≥2]			36-43	only if $I_3>0$
		$\overline{X}$	XENV		ppm average grade of the earth's crust
		ρ	RHO		specific gravity of the ore
		b/a	BDA		dimension ratios of the average
		c/b	CDB		deposit with $a \geq b \gg c \neq 0$
		J_1	ITAR(1)		≡1, year index,the target deposit is specified as:
		Z_1	RTAR(1)		tons of metal
		X_1	XTAR(1)		ppm average grade
					the sequential years,the same target deposit is used until:
		J_2	ITAR(2)		year index for which the target is:
		Z_2	RTAR(2)		tons of metal
		X_2	XTAR(2)		ppm average grade
					etc. until a card is given in which
		J_i	ITAR(i)		=0
D	1	N_y	NYEAR		total number of years of the considered period
		i_e	IE		average number of years between the start of an exploration and the evidence of an exploitable deposit
		i_p	IP		minimum number of years between the discovery of a deposit and its capitalization
E	1	M_o	EMo	12-13	initial capitalized reserves, tons of metal
		M'_o	EMAo		initial not capitalized reserves, tons of metal
		M''_{MIN}	EMAAo		minimum annual discovery rate, tons/year
F	1	Q	Q		market price $/ton of metal

ITEM	CARDS	SYMBOL	FORTRAN NAMES	RELATED EXPRESSIONS	
G	1	c	CRATIO	7	required ratio capitalized reserves/annual requirements
		a	ARATIO	19	allowed exploration costs as a fraction of the market price
		v	FINTER	15-16 21-30	interest rate as a fraction of 1
H	≥ 1	d_i	D(i)	12-13	tons of metal annual requirements to specify for each year of the considered period
I	[1-2]				only if $I_4>0$
		L	NLEV		=0; only automatic leveling is performed >0; L preference direction coefficients follow each of them give raise to an independent leveling
		a_i	ALE(i)	48-52	Only if L>0 L preference direction coefficients for the first leveling interval after the initial interval of i_e years.

PROBLEM input EXILE DATE PAGE OF

ITEM:	Card	Fields
A	1	I_1, I_2, I_3, I_4, I_5, K_1, K_2, K_3, K_4, - - - - - - - - - - -
B	2	r, z, X_r
C if I_3>0	3	$\overline{X}$, ρ, b/a, c/b
	4	J_1, Z_1, X_1
	5	J_2, Z_2, X_2
	6	- - - - - - - - - - - - - - - - - - - -
	7	- - - - - - - - - - - - - - - - - - - -
	8	0
D	9	N_y, i_e, i_p
E	10	M_o, M'_o, M''_{MIN}
F	11	Q
G	12	c, a
H	13	d_1, d_2, - - - - - - - - - - - - - - - - -, d_{N_y}
I if I_4>0	14	L
I if L >0	15	a_1, a_2, - - - - - - - - - - - - - -, a_L

The I, J, K, L, M and N names stay for fixed point constants.

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APPENDIX A

THE PREDICTABILITY OF MINERALS IN THE EARTH'S CRUST

This appendix gives a short summary of the theory of Mr. BRINCK on the predictability of minerals in the earth's crust. The main part of this chapter has been published previously (see ref. 1), but some additional items are new.

The log-normal distribution of the element concentrations is the basic concept of the theory and the applied calculations:

> The weighted frequencies of the logarithms of the element concentrations, estimated from a series of regionally related samples, can be fitted into a normal probability distribution.

The median concentration γ of a log-normal distribution is given by:

$$\log \gamma = \frac{\sum_{i=1}^{N} W_i \log X_i}{\sum_{i=1}^{N} W_i} \qquad (A.1)$$

in which: N is the number of samples
X_i is the element concentration in sample i
W_i is the weight of sample i.

The standard deviation σ is given by:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} W_i \left[\log X_i - \log \gamma\right]^2}{[N - 1] \sum_{i=1}^{N} W_i}} \qquad (A.2)$$

The standard deviation is a measure of the dispersion of the concentrations around the most frequent or median value γ, for the average sample size $\overline{W}$:

$$\overline{W} = \frac{\sum_{i=1}^{N} W_i}{N} \qquad (A.3)$$

The average concentration $\overline{X}$ is:

$$\overline{X} = \gamma . e^{0.5\sigma^2} \tag{A.4}$$

The probability of occurrence P_K of a concentration $\geq X_K$ with size $\overline{W}$ in the sample environment R may be calculated by:

$$\log X_K - \log \gamma_R = \sqrt{2}\ \mathrm{erf}^{-1}\left[1 - 2P_K\right]\ \sigma \tag{A.5}$$

or:

$$P_K = 0.5 - 0.5\ \mathrm{erf}\left[\frac{\log X_K - \log \gamma_R}{\sqrt{2}\ .\ \sigma}\right] \tag{A.6}$$

Thus the probable available total tonnage r_K of all concentrations $\geq X_K$, with an average weight of $\overline{W}$, in the environment R can be estimated:

$$r_K = P_K \times R \tag{A.7}$$

The absolute dispersion coefficient α has been defined to describe the probability of occurrence of concentrations with other weights than $\overline{W}$, in relation to the sample distribution.
The formula of MATHERON-DE WIJS introduces the absolute dispersion coefficient α:

$$\alpha = \frac{\sigma^2}{3 \log \frac{D}{d}} \qquad [0 \leq \alpha \leq 1] \tag{A.8}$$

in which D and d are respectively the linear equivalents of the sampled environment and of the average sample. The estimation of D and d will be described later.
This relation has been defined to compare the absolute grade contrast in different mineral deposits. α is a fractional value, $(0 \leq \alpha \leq 1)$, directly related to the environment R. It is invariant in relation to the collection of samples taken to evaluate the environment R. Of course, the accuracy of the estimation of α increases with increasing sample collection as does the other invariant constant, the average content $\overline{X}$.

The previous formulas may be collected into two expressions which relate the constants α and $\overline{X}$, (for a certain environment R), with the sample collection constants X_K, γ_R, d and r;

$$\alpha = \frac{100 \times \log^2 \left[\frac{X_K}{\gamma_R}\right]}{6 \log\left[\frac{D}{d}\right] \times \left[\mathrm{erf}^{-1} (1 - 2 \frac{r}{R})\right]} \% \qquad \text{(A.9)}$$

$$\frac{\overline{X}}{\gamma_R} = \exp\left[0.015\ \alpha \log \frac{D}{d}\right] \quad (\alpha \text{ in } \%) \qquad \text{(A.10)}$$

Another expression which is easily derived from the previous formulas, expresses γ_R directly:

$$\gamma_R = \exp\left[-2E^2 + \log X_K + 2E\sqrt{E^2 - \log X_K + \log \overline{X}}\right] \qquad \text{(A.11)}$$

in which: $E = \mathrm{erf}^{-1}\left[1 - 2\frac{r}{R}\right]$.

The linear equivalent d has been described by MATHERON. For the more exact derivation we must refer to the original paper (see references). An approximation may satisfy our goals: the linear equivalent of a volume with the dimensions a > b > c is roughly equal to:

$$d = a + b + c \qquad \text{(A.12)}$$

Generally, a volume of a deposit is given by the ratios b/a and c/b and its content V. The linear equivalent may then be calculated by:

$$a = \sqrt[3]{\frac{V}{[b/a]^2 \cdot [c/b]}} \quad (c \neq 0) \qquad \text{(A.13)}$$

$$d = a\left[1 + b/a + b/a \cdot c/b\right] \qquad \text{(A.14)}$$

The linear equivalent of a surface S is given by:

$$a = \sqrt{\frac{S}{b/a}} \quad (c = 0) \qquad \text{(A.15)}$$

$$d = a\left[1 + b/a\right] \qquad \text{(A.16)}$$

A numerical example of the application of the theory will illustrate the calculation method:

Considering all the known exploitable uranium ore reserves, the median individual reserve is estimated as 4000 tons of uranium at a median content of 1500 ppm. The total known reserves of this quality is about 500,000 tons of metal. The dimension ratios of the average deposit are b/a = 0.5 and c/b = 0.1. The specific gravity of uranium ore is about the same as for the earth's crust: 2.7 gr/cm^3.

These informations represent in fact an extreme part of the distribution curve for uranium in the earth's crust as environment. Combined with the data for the whole crust, one may calculate the distribution curves for different deposit sizes.
The additional data are: the dry land surface is 1.5 x 10^8 km^2. Taking into consideration a depth of 2.5 km, the weight of the environment is 10^{18} tons. The dimension ratios are taken as b/a = 1 and c/b = 0. The mean content of uranium in the crust is also known: $\overline{X}$ = 3 ppm (GREEN, 1959).

Collecting the data:

$$\frac{r}{R} = \frac{500{,}000 \times \frac{100}{0.15}}{10^{18}} = 3.33 \times 10^{-10} \qquad \text{(A.17)}$$

$$a = \sqrt[3]{\frac{4000 \times \frac{100}{0.15} \times 10^{-9} \times \frac{1}{2.7}}{0.5^2 \times 0.1}} = 0.34 \text{ km} \qquad \text{(A.18)}$$

$$d = 0.34 \left[1 + 0.5 + 0.05\right] = 0.53 \qquad \text{(A.19)}$$

$$D = \sqrt{\frac{150 \times 10^6}{1}} \times \left[1 + 1\right] = 24{,}400 \text{ km} \qquad \text{(A.20)}$$

$$\frac{d}{D} = 2.2 \times 10^{-5} \qquad \text{(A.21)}$$

$$X_K = 1{,}500 \text{ ppm} \qquad \text{(A.22)}$$

$$\overline{X} = 3 \text{ ppm} \qquad \text{(A.23)}$$

Applying expression (A.11), the γ_R for samples with a linear equivalent d can be calculated:

$$\gamma_R = 1.627 \text{ ppm} \quad (A.24)$$

Sequentially, α may be calculated with expression (A.9):

$$\alpha = 3.80 \% \quad (A.25)$$

The absolute dispersion coefficient α and the mean content $\overline{X}$, enable us to calculate the probability of occurrence of all deposit sizes and grades. Take for example, a target deposit of 10,000 tons of uranium with a grade of X_K = 1000 ppm. The next calculations may be performed:

$$V = \frac{10,000}{1000} \times \frac{1}{2.7} \times 10^6 \times 10^{-9} \text{ km}^3 = 0.370 \times 10^{-2} \text{ km}^3 \quad (A.26)$$

$$a = \sqrt[3]{\frac{0.370 \times 10^{-2}}{0.025}} = 0.529 \text{ km} \quad (A.27)$$

$$d = 0.529 \times 1.55 = 0.820 \text{ km} \quad (A.28)$$

$$\frac{D}{d} = \frac{24,400}{0.820} = 0.298 \times 10^5 \quad (A.29)$$

$$\frac{\overline{X}}{\gamma_R} = \exp\left[0.015 \times \alpha \times \log\left[0.298 \times 10^5\right]\right] \text{(expr.(A.10))} \quad (A.30)$$

$$\gamma_R = 1.69 \quad (A.31)$$

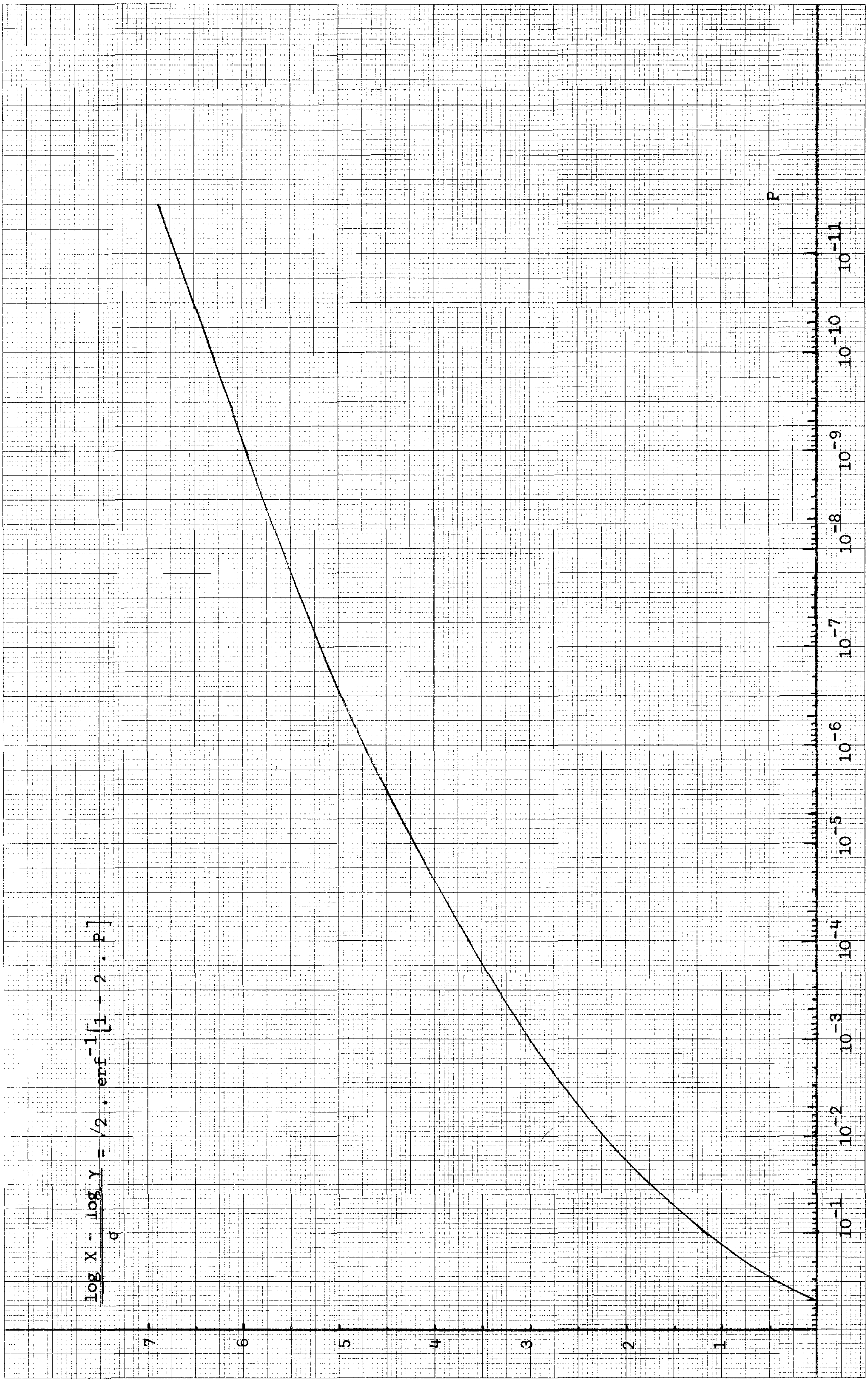
$$\sigma = \sqrt{2 \times \log \frac{3}{1.69}} = 1.084 \qquad \text{(expr.(A.4))} \quad (A.32)$$

$$\frac{\log X_K - \log \gamma_R}{\sigma} = 5.91 \quad (A.33)$$

$$P_K = 1.7 \times 10^{-9} \qquad \text{(expr.(A.6) and graph 1.)} \quad (A.34)$$

$$r = 1.7 \times 10^{-9} \times 10^{18} = 1.7 \times 10^9 \text{ tons of ore} \quad (A.35)$$

which is equivalent to 1.7×10^6 tons of uranium. As each deposit contains 10,000 tons of uranium, it is expected that the earth's crust may deliver ultimately 170 deposits of this type.


$\frac{\log X - \log Y}{\sigma} = \sqrt{2} \cdot erf^{-1}[1 - 2 \cdot P]$
7
6
5
4
3
2
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
P

APPENDIX B

AN INPUT AND OUTPUT EXAMPLE

This Appendix gives an input and corresponding output example of the EXILE program. The calculations concern the investments for the exploration of uranium during a period of 20 years. A limited graphical output is also given. After the leveling procedure, the same graphs as for the non leveled case are drawn, so some graphs, for example the annual requirements, are given two times.

The target deposits are assumed to increase in size and decrease in grade gradually: for each year another target deposit has been specified.

CETIS/CADI (EURATOM)

PROBLEM INPUT EXAMPLE EXILE | DATE | PAGE 1 OF 2

```
         1         2         3         4         5         6
123456789012345678901234567890123456789012345678901234567890123
     1           1     1     1              1  2  6  8  9 14 15
  5.0    E+5  4.     E+3  1.5    E+3
  3.0         2.7         0.5         0.1
     1  4000.       1500.
     2  4317.       1450.
     3  4660.       1402.
     4  5030.       1355.
     5  5429.       1310.
     6  5860.       1266.
     7  6325.       1224.
     8  6827.       1183.
     9  7369.       1144.
    10  7954.       1106.
    11  8585.       1063.
    12  9266.       1033.
    13 10001.        999.
    14 10795.        966.
    15 11652.        934.
    16 12577.        903.
    17 13575.        873.
    18 14652.        844.
    19 15815.        816.
    20 17070.        789.
     0
```

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PROBLEM INPUT EXAMPLE EXILE DATE PAGE 2 OF 2

```
    20     5     3
  3.5    E+4 3.5     E+4  4.5    E+3
  2.1    E+4
 15.0        0.1         0.07
  1654.       2096.       2585.       3124.       3617.       4186.
  4794.       5444.       6138.       6878.       7667.       8506.
  9398.      10347.      11744.      11538.      12410.      13282.
 14209.      15192.
     0
```


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INPUT DATA
****

TOTAL WORLD RESERVES	0.5000E 06	TONS METAL
AVERAGE ORE DEPOSIT	0.4000E 04	TONS METAL
AVERAGE GRADE RESERVES	0.1500E 04	PPM
AVERAGE CONTENT IN CRUST	0.3000E 01	PPM
SPECIFIC GRAVITY	0.2700E 01	GR/CM3
DIMENSION RATIO B/A	0.5000E 00	
DIMENSION RATIO C/B	0.1000E 00	
GAMMA (CALCULATED)	0.1627E 01	PPM
ALFA (CALCULATED)	0.3796E 01	PERCENT
TOTAL TIME	20	YEARS
EXPLORATION UNTIL DISCOVERY	5	YEARS
CAPITALIZATION TIME	3	YEARS
MINIMUM ANNUAL EXPLORATION	0.4500E 04	TONS METAL
PRICE OF CAPITALIZED PRODUCT	0.2100E 05	$
EXPLORATION FRACTION OF PRICE	0.1000E 00	
RESERVES / ANNUAL CONSUMPTION	0.1500E 02	
INTEREST RATE	0.7000E 01	PERCENT

NON-LEVELED STOCKTABLE
****

YEAR	ANNUAL REQUIREMENT	CUMULATIVE REQUIREMENT	CUMULATIVE CAPITALIZED RESERVES	RATIO CAP. RES.	CAPITALIZED ANNUAL	CUM. NOT CAPITALIZED RESERVES	RATIO TOTAL RES.	ANNUAL DISCOVERY RATE	TOTAL RESERVES
			0.3500E 05			0.3500E 05			
1	0.1654E 04	0.1654E 04	0.3335E 05	20.2	0.0	0.3950E 05	44.0	0.4500E 04	0.7285E 05
2	0.2096E 04	0.3750E 04	0.3144E 05	15.0	0.1900E 03	0.4381E 05	35.9	0.4500E 04	0.7525E 05
3	0.2585E 04	0.6335E 04	0.3877E 05	15.0	0.9920E 04	0.3839E 05	29.9	0.4500E 04	0.7716E 05
4	0.3124E 04	0.9459E 04	0.4636E 05	15.0	0.1121E 05	0.3765E 05	27.1	0.1047E 05	0.8451E 05
5	0.3617E 04	0.1308E 05	0.5425E 05	15.0	0.1101E 05	0.4183E 05	26.6	0.1519E 05	0.9608E 05
6	0.4186E 04	0.1726E 05	0.6279E 05	15.0	0.1272E 05	0.4566E 05	25.9	0.1655E 05	0.1084E 06
7	0.4794E 04	0.2206E 05	0.7191E 05	15.0	0.1391E 05	0.4972E 05	25.4	0.1798E 05	0.1216E 06
8	0.5444E 04	0.2750E 05	0.8166E 05	15.0	0.1519E 05	0.5403E 05	24.9	0.1950E 05	0.1357E 06
9	0.6138E 04	0.3364E 05	0.9207E 05	15.0	0.1655E 05	0.5857E 05	24.5	0.2109E 05	0.1506E 06
10	0.6878E 04	0.4052E 05	0.1032E 06	15.0	0.1798E 05	0.6337E 05	24.2	0.2278E 05	0.1665E 06
11	0.7667E 04	0.4818E 05	0.1150E 06	15.0	0.1950E 05	0.6845E 05	23.9	0.2458E 05	0.1835E 06
12	0.8506E 04	0.5669E 05	0.1276E 06	15.0	0.2109E 05	0.8006E 05	24.4	0.3270E 05	0.2076E 06
13	0.9398E 04	0.6609E 05	0.1410E 06	15.0	0.2278E 05	0.6653E 05	22.1	0.9248E 04	0.2075E 06
14	0.1035E 05	0.7643E 05	0.1552E 06	15.0	0.2458E 05	0.6669E 05	21.4	0.2474E 05	0.2219E 06
15	0.1174E 05	0.8818E 05	0.1762E 06	15.0	0.3270E 05	0.6035E 05	20.1	0.2636E 05	0.2365E 06
16	0.1159E 05	0.9977E 05	0.1738E 06	15.0	0.9248E 04	0.7922E 05	21.8	0.2811E 05	0.2530E 06
17	0.1241E 05	0.1122E 06	0.1861E 06	15.0	0.2474E 05	0.8441E 05	21.8	0.2994E 05	0.2706E 06
18	0.1328E 05	0.1255E 06	0.1992E 06	15.0	0.2636E 05	0.6255E 05	19.7	0.4500E 04	0.2618E 06
19	0.1421E 05	0.1397E 06	0.2131E 06	15.0	0.2811E 05	0.4393E 05	18.1	0.9490E 04	0.2571E 06
20	0.1519E 05	0.1549E 06	0.2279E 06	15.0	0.2994E 05	0.2822E 05	16.9	0.1423E 05	0.2561E 06

YEAR	NET INV. PER TON ON DISC.R.	ANNUAL TOTAL NET INVESTMENT	ANNUAL INCOME	CUMULATIVE INVESTMENT	NEW INVESTMENT
	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $
				0.7052E 02	
1	1217.	0.1061E 02	0.0	0.8681E 02	0.1061E 02
2	1302.	0.1412E 02	0.3990E 00	0.1076E 03	0.1065E 02
3	1323.	0.1796E 02	0.2083E 02	0.1135E 03	0.1356E 02
4	1393.	0.2220E 02	0.2364E 02	0.1217E 03	0.1677E 02
5	1393.	0.2516E 02	0.2313E 02	0.1340E 03	0.1860E 02
6	1393.	0.2727E 02	0.2671E 02	0.1458E 03	0.1968E 02
7	1393.	0.2951E 02	0.2922E 02	0.1584E 03	0.2072E 02
8	1393.	0.3361E 02	0.3191E 02	0.1735E 03	0.2354E 02
9	1393.	0.3076E 02	0.3475E 02	0.1838E 03	0.1932E 02
10	1393.	0.3177E 02	0.3775E 02	0.1930E 03	0.1888E 02
11	1393.	0.3277E 02	0.4095E 02	0.2006E 03	0.1833E 02
12	1393.	0.3375E 02	0.4429E 02	0.2064E 03	0.1765E 02
13	1393.	0.3299E 02	0.4783E 02	0.2084E 03	0.1512E 02
14	1393.	0.3158E 02	0.5162E 02	0.2051E 03	0.1184E 02
15	1393.	0.2733E 02	0.6867E 02	0.1800E 03	0.5603E 01
16	1393.	0.2395E 02	0.1942E 02	0.1989E 03	-0.7110E 00
17	1393.	0.2008E 02	0.5195E 02	0.1823E 03	-0.4252E 01
18	1302.	0.1571E 02	0.5536E 02	0.1565E 03	-0.1035E 02
19	1393.	0.1850E 02	0.5904E 02	0.1282E 03	-0.9394E 01
20	1393.	0.1982E 02	0.6287E 02	0.9554E 02	-0.1002E 02
	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $

TABLE OF EXPLORATION AREAS
****

TARGET DEPOSIT IS AVERAGE DEPOSIT
SIZE = 0.4000E 04 TONS METAL
GRADE= 0.1500E 04 PPM

YEAR	ANNUAL DISCOVERY RATE	ANNUAL NET INVESTMENT $	EXPLORE SURFACE KM2	EXPL PRICE $/KM2	NUMBER OF DEPOSITS
1	4500.	10605979.	0.4558E 07	2.33	3.80
2	4500.	14121065.	0.4964E 07	2.84	4.14
3	4500.	17957872.	0.5393E 07	3.33	4.49
4	10466.	22200096.	0.5851E 07	3.79	4.88
5	15194.	25160064.	0.6327E 07	3.98	5.27
6	16548.	27272880.	0.6833E 07	3.99	5.69
7	17978.	29511056.	0.7375E 07	4.00	6.15
8	19502.	33612144.	0.9810E 07	3.43	8.17
9	21091.	30755504.	0.2774E 07	11.09	2.31
10	22778.	31772064.	0.7422E 07	4.28	6.18
11	24582.	32770544.	0.7909E 07	4.14	6.59
12	32699.	33754512.	0.8434E 07	4.00	7.03
13	9248.	32985040.	0.8981E 07	3.67	7.48
14	24740.	31580288.	0.1350E 07	23.39	1.12
15	26362.	27331888.	0.2847E 07	9.60	2.37
16	28114.	23951408.	0.4268E 07	5.61	3.56
17	29937.	20082848.	0.4268E 07	4.71	3.56
18	4500.	15706421.	0.4268E 07	3.68	3.56
19	9490.	18498416.	0.4268E 07	4.33	3.56
20	14228.	19818192.	0.4268E 07	4.64	3.56

TABLE OF EXPLORATION AREAS
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TARGET DEPOSITS ARE SPECIFIED

YEAR	ANNUAL DISCOVERY RATE	ANNUAL NET INVESTMENT $	TARGET DEPOSITS TONS METAL	GRADE	EXPLORE SURFACE KM2	EXPL PRICE $/KM2	NUMBER OF DEPOSITS	PROBABLE UNIT COST $/TON
1	4500.	10605979.	4000.	1500.	0.4537E 07	2.34	3.80	2090.
2	4500.	14121065.	4317.	1450.	0.4437E 07	3.18	3.83	2020.
3	4500.	17957872.	4660.	1402.	0.4332E 07	4.15	3.86	1954.
4	10466.	22200096.	5030.	1355.	0.4215E 07	5.27	3.88	1886.
5	15194.	25160064.	5429.	1310.	0.4094E 07	6.15	3.88	1823.
6	16548.	27272880.	5860.	1266.	0.3964E 07	6.88	3.89	1759.
7	17978.	29511056.	6325.	1224.	0.3842E 07	7.68	3.89	1700.
8	19502.	33612144.	6827.	1183.	0.4582E 07	7.34	4.79	1641.
9	21091.	30755504.	7369.	1144.	0.1165E 07	26.40	1.25	1587.
10	22778.	31772064.	7954.	1106.	0.2797E 07	11.36	3.11	1533.
11	24582.	32770544.	8585.	1069.	0.2672E 07	12.26	3.07	1480.
12	32699.	33754512.	9266.	1033.	0.2552E 07	13.23	3.03	1427.
13	9248.	32985040.	10001.	999.	0.2442E 07	13.51	2.99	1379.
14	24740.	31580288.	10795.	966.	0.3296E 06	95.82	0.42	1333.
15	26362.	27331888.	11652.	934.	0.6238E 06	43.81	0.81	1287.
16	28114.	23951408.	12577.	903.	0.8390E 06	28.55	1.13	1243.
17	29937.	20082848.	13575.	873.	0.7525E 06	26.69	1.05	1199.
18	4500.	15706421.	14652.	844.	0.6748E 06	23.28	0.97	1158.
19	9490.	18498416.	15815.	816.	0.6052E 06	30.57	0.90	1117.
20	14228.	19818192.	17070.	789.	0.5429E 06	36.50	0.83	1078.

LEVELED STOCKTABLE
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YEAR	ANNUAL REQUIREMENT	CUMULATIVE REQUIREMENT	CUMULATIVE CAPITALIZED RESERVES	RATIO CAP. RES.	CAPITALIZED ANNUAL	CUM. NOT CAPITALIZED RESERVES	RATIO TOTAL RES.	ANNUAL DISCOVERY RATE	TOTAL RESERVES
			0.3500E 05			0.3500E 05			
1	0.1654E 04	0.1654E 04	0.3335E 05	20.2	0.0	0.3965E 05	44.1	0.4649E 04	0.7300E 05
2	0.2096E 04	0.3750E 04	0.3144E 05	15.0	0.1900E 03	0.4500E 05	36.5	0.5544E 04	0.7644E 05
3	0.2585E 04	0.6335E 04	0.3377E 05	15.0	0.9920E 04	0.4152E 05	31.1	0.6439E 04	0.8030E 05
4	0.3124E 04	0.9459E 04	0.4686E 05	15.0	0.1121E 05	0.3765E 05	27.1	0.7334E 04	0.8451E 05
5	0.3617E 04	0.1308E 05	0.5425E 05	15.0	0.1101E 05	0.4183E 05	26.6	0.1519E 05	0.9608E 05
6	0.4186E 04	0.1726E 05	0.6279E 05	15.0	0.1272E 05	0.4605E 05	26.0	0.1694E 05	0.1088E 06
7	0.4794E 04	0.2206E 05	0.7191E 05	15.0	0.1391E 05	0.5081E 05	25.6	0.1868E 05	0.1227E 06
8	0.5444E 04	0.2750E 05	0.8166E 05	15.0	0.1519E 05	0.5604E 05	25.3	0.2042E 05	0.1377E 06
9	0.6138E 04	0.3364E 05	0.9207E 05	15.0	0.1655E 05	0.6166E 05	25.0	0.2217E 05	0.1537E 06
10	0.6878E 04	0.4052E 05	0.1032E 06	15.0	0.1798E 05	0.6760E 05	24.8	0.2391E 05	0.1708E 06
11	0.7667E 04	0.4818E 05	0.1150E 06	15.0	0.1950E 05	0.7375E 05	24.6	0.2566E 05	0.1888E 06
12	0.8506E 04	0.5669E 05	0.1276E 06	15.0	0.2109E 05	0.8006E 05	24.4	0.2740E 05	0.2076E 06
13	0.9398E 04	0.6609E 05	0.1410E 06	15.0	0.2278E 05	0.8344E 05	23.9	0.2616E 05	0.2244E 06
14	0.1035E 05	0.7643E 05	0.1552E 06	15.0	0.2458E 05	0.8378E 05	23.1	0.2492E 05	0.2390E 06
15	0.1174E 05	0.3818E 05	0.1762E 06	15.0	0.3270E 05	0.7476E 05	21.4	0.2368E 05	0.2509E 06
16	0.1159E 05	0.9977E 05	0.1738E 06	15.0	0.9248E 04	0.8795E 05	22.6	0.2244E 05	0.2618E 06
17	0.1241E 05	0.1122E 06	0.1861E 06	15.0	0.2474E 05	0.8441E 05	21.8	0.2120E 05	0.2706E 06
18	0.1328E 05	0.1255E 06	0.1992E 06	15.0	0.2636E 05	0.7743E 05	20.8	0.1938E 05	0.2767E 06
19	0.1421E 05	0.1397E 06	0.2131E 06	15.0	0.2811E 05	0.6687E 05	19.7	0.1755E 05	0.2800E 06
20	0.1519E 05	0.1549E 06	0.2279E 06	15.0	0.2994E 05	0.5266E 05	18.5	0.1573E 05	0.2805E 06

YEAR	NET INV. PER TON ON DISC.R.	ANNUAL TOTAL NET INVESTMENT	ANNUAL INCOME	CUMULATIVE INVESTMENT	NEW INVESTMENT
	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $
				0.7176E 02	
1	1217.	0.1052E 02	0.0	0.8805E 02	0.1052E 02
2	1300.	0.1410E 02	0.3990E 00	0.1089E 03	0.1063E 02
3	1302.	0.1785E 02	0.2083E 02	0.1148E 03	0.1345E 02
4	1393.	0.2183E 02	0.2354E 02	0.1226E 03	0.1640E 02
5	1393.	0.2590E 02	0.2313E 02	0.1358E 03	0.1934E 02
6	1391.	0.2825E 02	0.2671E 02	0.1488E 03	0.2066E 02
7	1388.	0.3059E 02	0.2922E 02	0.1628E 03	0.2180E 02
8	1384.	0.3304E 02	0.3191E 02	0.1776E 03	0.2297E 02
9	1380.	0.3437E 02	0.3475E 02	0.1921E 03	0.2293E 02
10	1377.	0.3488E 02	0.3775E 02	0.2051E 03	0.2199E 02
11	1374.	0.3463E 02	0.4095E 02	0.2155E 03	0.2018E 02
12	1393.	0.3367E 02	0.4429E 02	0.2224E 03	0.1757E 02
13	1334.	0.3194E 02	0.4783E 02	0.2243E 03	0.1408E 02
14	1330.	0.2992E 02	0.5162E 02	0.2204E 03	0.1018E 02
15	1337.	0.2771E 02	0.6867E 02	0.1968E 03	0.5980E 01
16	1357.	0.2530E 02	0.1942E 02	0.2182E 03	0.6333E 00
17	1393.	0.2266E 02	0.5195E 02	0.2057E 03	-0.1679E 01
18	1278.	0.1976E 02	0.5536E 02	0.1859E 03	-0.6298E 01
19	1260.	0.1742E 02	0.5904E 02	0.1585E 03	-0.1048E 02
20	1247.	0.1519E 02	0.6287E 02	0.1230E 03	-0.1465E 02
	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $

TABLE OF EXPLORATION AREAS
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TARGET DEPOSIT IS AVERAGE DEPOSIT
SIZE = 0.4000E 04 TONS METAL
GRADE= 0.1500E 04 PPM

YEAR	ANNUAL DISCOVERY RATE	ANNUAL NET INVESTMENT $	EXPLORE SURFACE KM2	EXPL PRICE $/KM2	NUMBER OF DEPOSITS
1	4649.	10524775.	0.4558E 07	2.31	3.80
2	5544.	14104998.	0.5081E 07	2.78	4.23
3	6439.	17848352.	0.5604E 07	3.18	4.67
4	7334.	21825232.	0.6127E 07	3.56	5.11
5	15194.	25901552.	0.6650E 07	3.89	5.54
6	16938.	28253216.	0.7174E 07	3.94	5.98
7	18681.	30592400.	0.7697E 07	3.97	6.41
8	20425.	33041008.	0.8220E 07	4.02	6.85
9	22168.	34367136.	0.7848E 07	4.38	6.54
10	23912.	34878544.	0.7476E 07	4.67	6.23
11	25655.	34628416.	0.7104E 07	4.87	5.92
12	27399.	33670176.	0.6732E 07	5.00	5.61
13	26159.	31943504.	0.6360E 07	5.02	5.30
14	24920.	29917440.	0.5813E 07	5.15	4.84
15	23680.	27708528.	0.5266E 07	5.26	4.39
16	22441.	25295712.	0.4719E 07	5.36	3.93
17	21201.	22655504.	0.4172E 07	5.43	3.48
18	19377.	19763168.	0.3625E 07	5.45	3.02
19	17554.	17416560.	0.3078E 07	5.66	2.56
20	15730.	15191046.	0.2531E 07	6.00	2.11

TABLE OF EXPLORATION AREAS
****

TARGET DEPOSITS ARE SPECIFIED

YEAR	ANNUAL DISCOVERY RATE	ANNUAL NET INVESTMENT $	TARGET DEPOSITS TONS METAL	GRADE	EXPLORE SURFACE KM2	EXPL PRICE $/KM2	NUMBER OF DEPOSITS	PROBABLE UNIT COST $/TON
1	4649.	10524775.	4000.	1500.	0.4537E 07	2.32	3.80	2090.
2	5544.	14104998.	4317.	1450.	0.4541E 07	3.11	3.92	2020.
3	6439.	17848352.	4660.	1402.	0.4501E 07	3.97	4.01	1954.
4	7334.	21825232.	5030.	1355.	0.4414E 07	4.94	4.06	1886.
5	15194.	25901552.	5429.	1310.	0.4303E 07	6.02	4.08	1823.
6	16938.	28253216.	5860.	1266.	0.4161E 07	6.79	4.08	1759.
7	18681.	30592400.	6325.	1224.	0.4009E 07	7.63	4.06	1700.
8	20425.	33041008.	6827.	1183.	0.3840E 07	8.61	4.01	1641.
9	22168.	34367136.	7369.	1144.	0.3295E 07	10.43	3.55	1587.
10	23912.	34878544.	7954.	1106.	0.2817E 07	12.38	3.13	1533.
11	25655.	34628416.	8585.	1069.	0.2400E 07	14.43	2.76	1480.
12	27399.	33670176.	9266.	1033.	0.2037E 07	16.53	2.42	1427.
13	26159.	31943504.	10001.	999.	0.1729E 07	18.47	2.12	1379.
14	24920.	29917440.	10795.	966.	0.1419E 07	21.08	1.80	1333.
15	23680.	27708528.	11652.	934.	0.1154E 07	24.01	1.51	1287.
16	22441.	25295712.	12577.	903.	0.9276E 06	27.27	1.25	1243.
17	21201.	22655504.	13575.	873.	0.7355E 06	30.80	1.02	1199.
18	19377.	19763168.	14652.	844.	0.5731E 06	34.48	0.82	1158.
19	17554.	17416560.	15815.	816.	0.4364E 06	39.91	0.65	1117.
20	15730.	15191046.	17070.	789.	0.3219E 06	47.19	0.49	1078.

LEVELED STOCKTABLE
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YEAR	ANNUAL REQUIREMENT	CUMULATIVE REQUIREMENT	CUMULATIVE CAPITALIZED RESERVES	RATIO CAP. RES.	CAPITALIZED ANNUAL	CUM. NOT CAPITALIZED RESERVES	RATIO TOTAL RES.	ANNUAL DISCOVERY RATE	TOTAL RESERVES
			0.3500E 05			0.3500E 05			
1	0.1654E 04	0.1654E 04	0.3335E 05	20.2	0.0	0.3965E 05	44.1	0.4649E 04	0.7300E 05
2	0.2096E 04	0.3750E 04	0.3144E 05	15.0	0.1900E 03	0.4500E 05	36.5	0.5544E 04	0.7644E 05
3	0.2585E 04	0.6335E 04	0.3877E 05	15.0	0.9920E 04	0.4152E 05	31.1	0.6439E 04	0.8030E 05
4	0.3124E 04	0.9459E 04	0.4686E 05	15.0	0.1121E 05	0.3765E 05	27.1	0.7334E 04	0.8451E 05
5	0.3617E 04	0.1308E 05	0.5425E 05	15.0	0.1101E 05	0.4183E 05	26.6	0.1519E 05	0.9608E 05
6	0.4186E 04	0.1726E 05	0.6279E 05	15.0	0.1272E 05	0.4605E 05	26.0	0.1694E 05	0.1088E 06
7	0.4794E 04	0.2206E 05	0.7191E 05	15.0	0.1391E 05	0.5081E 05	25.6	0.1868E 05	0.1227E 06
8	0.5444E 04	0.2750E 05	0.8166E 05	15.0	0.1519E 05	0.5604E 05	25.3	0.2042E 05	0.1377E 06
9	0.6138E 04	0.3364E 05	0.9207E 05	15.0	0.1655E 05	0.6166E 05	25.0	0.2217E 05	0.1537E 06
10	0.6878E 04	0.4052E 05	0.1032E 06	15.0	0.1798E 05	0.6760E 05	24.8	0.2391E 05	0.1708E 06
11	0.7667E 04	0.4818E 05	0.1150E 06	15.0	0.1950E 05	0.7375E 05	24.6	0.2566E 05	0.1888E 06
12	0.8506E 04	0.5669E 05	0.1276E 06	15.0	0.2109E 05	0.8006E 05	24.4	0.2740E 05	0.2076E 06
13	0.9398E 04	0.6609E 05	0.1410E 06	15.0	0.2278E 05	0.8344E 05	23.9	0.2616E 05	0.2244E 06
14	0.1035E 05	0.7643E 05	0.1552E 06	15.0	0.2458E 05	0.8378E 05	23.1	0.2492E 05	0.2390E 06
15	0.1174E 05	0.3818E 05	0.1762E 06	15.0	0.3270E 05	0.7476E 05	21.4	0.2368E 05	0.2509E 06
16	0.1159E 05	0.9977E 05	0.1738E 06	15.0	0.9248E 04	0.8795E 05	22.6	0.2244E 05	0.2618E 06
17	0.1241E 05	0.1122E 06	0.1861E 06	15.0	0.2474E 05	0.8441E 05	21.8	0.2120E 05	0.2706E 06
18	0.1328E 05	0.1255E 06	0.1992E 06	15.0	0.2636E 05	0.7743E 05	20.8	0.1938E 05	0.2767E 06
19	0.1421E 05	0.1397E 06	0.2131E 06	15.0	0.2811E 05	0.6687E 05	19.7	0.1755E 05	0.2800E 06
20	0.1519E 05	0.1549E 06	0.2279E 06	15.0	0.2994E 05	0.5266E 05	18.5	0.1573E 05	0.2805E 06

YEAR	NET INV. PER TON ON DISC.R.	ANNUAL TOTAL NET INVESTMENT	ANNUAL INCOME	CUMULATIVE INVESTMENT	NEW INVESTMENT
	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $
				0.7176E 02	
1	1217.	0.1052E 02	0.0	0.8805E 02	0.1052E 02
2	1300.	0.1410E 02	0.3990E 00	0.1089E 03	0.1063E 02
3	1302.	0.1785E 02	0.2083E 02	0.1148E 03	0.1345E 02
4	1393.	0.2183E 02	0.2354E 02	0.1226E 03	0.1640E 02
5	1393.	0.2590E 02	0.2313E 02	0.1358E 03	0.1934E 02
6	1391.	0.2825E 02	0.2671E 02	0.1488E 03	0.2066E 02
7	1388.	0.3059E 02	0.2922E 02	0.1628E 03	0.2180E 02
8	1384.	0.3304E 02	0.3191E 02	0.1776E 03	0.2297E 02
9	1380.	0.3437E 02	0.3475E 02	0.1921E 03	0.2293E 02
10	1377.	0.3488E 02	0.3775E 02	0.2051E 03	0.2199E 02
11	1374.	0.3463E 02	0.4095E 02	0.2155E 03	0.2018E 02
12	1393.	0.3367E 02	0.4429E 02	0.2224E 03	0.1757E 02
13	1334.	0.3194E 02	0.4783E 02	0.2243E 03	0.1408E 02
14	1330.	0.2992E 02	0.5162E 02	0.2204E 03	0.1018E 02
15	1337.	0.2771E 02	0.6867E 02	0.1968E 03	0.5980E 01
16	1357.	0.2530E 02	0.1942E 02	0.2182E 03	0.6333E 00
17	1393.	0.2266E 02	0.5195E 02	0.2057E 03	-0.1679E 01
18	1278.	0.1976E 02	0.5536E 02	0.1859E 03	-0.6298E 01
19	1260.	0.1742E 02	0.5904E 02	0.1585E 03	-0.1048E 02
20	1247.	0.1519E 02	0.6287E 02	0.1230E 03	-0.1465E 02

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TABLE OF EXPLORATION AREAS
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TARGET DEPOSIT IS AVERAGE DEPOSIT
SIZE = 0.4000E 04 TONS METAL
GRADE= 0.1500E 04 PPM

YEAR	ANNUAL DISCOVERY RATE	ANNUAL NET INVESTMENT $	EXPLORE SURFACE KM2	EXPL PRICE $/KM2	NUMBER OF DEPOSITS
1	4649.	10524775.	0.4558E 07	2.31	3.80
2	5544.	14104998.	0.5081E 07	2.78	4.23
3	6439.	17848352.	0.5604E 07	3.18	4.67
4	7334.	21825232.	0.6127E 07	3.56	5.11
5	15194.	25901552.	0.6650E 07	3.89	5.54
6	16938.	28253216.	0.7174E 07	3.94	5.98
7	18681.	30592400.	0.7697E 07	3.97	6.41
8	20425.	33041008.	0.8220E 07	4.02	6.85
9	22168.	34367136.	0.7848E 07	4.38	6.54
10	23912.	34378544.	0.7476E 07	4.67	6.23
11	25655.	34628416.	0.7104E 07	4.87	5.92
12	27399.	33670176.	0.6732E 07	5.00	5.61
13	26159.	31943504.	0.6360E 07	5.02	5.30
14	24920.	29917440.	0.5813E 07	5.15	4.84
15	23680.	27708528.	0.5266E 07	5.26	4.39
16	22441.	25295712.	0.4719E 07	5.36	3.93
17	21201.	22655504.	0.4172E 07	5.43	3.48
18	19377.	19763168.	0.3625E 07	5.45	3.02
19	17554.	17416560.	0.3078E 07	5.66	2.56
20	15730.	15191046.	0.2531E 07	6.00	2.11

TABLE OF EXPLORATION AREAS
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TARGET DEPOSITS ARE SPECIFIED

YEAR	ANNUAL DISCOVERY RATE	ANNUAL NET INVESTMENT $	TARGET DEPOSITS TONS METAL	GRADE	EXPLORE SURFACE KM2	EXPL PRICE $/KM2	NUMBER OF DEPOSITS	PROBABLE UNIT COST $/TON
1	4649.	10524775.	4000.	1500.	0.4537E 07	2.32	3.80	2090.
2	5544.	14104998.	4317.	1450.	0.4541E 07	3.11	3.92	2020.
3	6439.	17848352.	4660.	1402.	0.4501E 07	3.97	4.01	1954.
4	7334.	21825232.	5030.	1355.	0.4414E 07	4.94	4.06	1886.
5	15194.	25901552.	5429.	1310.	0.4303E 07	6.02	4.08	1823.
6	16938.	28253216.	5860.	1266.	0.4161E 07	6.79	4.08	1759.
7	18681.	30592400.	6325.	1224.	0.4009E 07	7.63	4.06	1700.
8	20425.	33041008.	6827.	1183.	0.3840E 07	8.61	4.01	1641.
9	22168.	34367136.	7369.	1144.	0.3295E 07	10.43	3.55	1587.
10	23912.	34878544.	7954.	1106.	0.2817E 07	12.38	3.13	1533.
11	25655.	34628416.	8585.	1069.	0.2400E 07	14.43	2.76	1480.
12	27399.	33670176.	9266.	1033.	0.2037E 07	16.53	2.42	1427.
13	26159.	31943504.	10001.	999.	0.1729E 07	18.47	2.12	1379.
14	24920.	29917440.	10795.	966.	0.1419E 07	21.08	1.80	1333.
15	23680.	27708528.	11652.	934.	0.1154E 07	24.01	1.51	1287.
16	22441.	25295712.	12577.	903.	0.9276E 06	27.27	1.25	1243.
17	21201.	22655504.	13575.	873.	0.7355E 06	30.80	1.02	1199.
18	19377.	19763168.	14652.	844.	0.5731E 06	34.48	0.82	1158.
19	17554.	17416560.	15815.	816.	0.4364E 06	39.91	0.65	1117.
20	15730.	15191046.	17070.	789.	0.3219E 06	47.19	0.49	1078.

LEVELED STOCKTABLE
****

YEAR	ANNUAL REQUIREMENT	CUMULATIVE REQUIREMENT	CUMULATIVE CAPITALIZED RESERVES	RATIO CAP. RES.	CAPITALIZED ANNUAL	CUM. NOT CAPITALIZED RESERVES	RATIO TOTAL RES.	ANNUAL DISCOVERY RATE	TOTAL RESERVES
			0.3500E 05			0.3500E 05			
1	0.1654E 04	0.1654E 04	0.3335E 05	20.2	0.0	0.3965E 05	44.1	0.4649E 04	0.7300E 05
2	0.2096E 04	0.3750E 04	0.3144E 05	15.0	0.1900E 03	0.4500E 05	36.5	0.5544E 04	0.7644E 05
3	0.2585E 04	0.6335E 04	0.3877E 05	15.0	0.9920E 04	0.4152E 05	31.1	0.6439E 04	0.8030E 05
4	0.3124E 04	0.9459E 04	0.4686E 05	15.0	0.1121E 05	0.3765E 05	27.1	0.7334E 04	0.8451E 05
5	0.3617E 04	0.1308E 05	0.5425E 05	15.0	0.1101E 05	0.4183E 05	26.6	0.1519E 05	0.9608E 05
6	0.4186E 04	0.1726E 05	0.6279E 05	15.0	0.1272E 05	0.4605E 05	26.0	0.1694E 05	0.1088E 06
7	0.4794E 04	0.2206E 05	0.7191E 05	15.0	0.1391E 05	0.5081E 05	25.6	0.1868E 05	0.1227E 06
8	0.5444E 04	0.2750E 05	0.8166E 05	15.0	0.1519E 05	0.5604E 05	25.3	0.2042E 05	0.1377E 06
9	0.6138E 04	0.3364E 05	0.9207E 05	15.0	0.1655E 05	0.6166E 05	25.0	0.2217E 05	0.1537E 06
10	0.6878E 04	0.4052E 05	0.1032E 06	15.0	0.1798E 05	0.6760E 05	24.8	0.2391E 05	0.1708E 06
11	0.7667E 04	0.4818E 05	0.1150E 06	15.0	0.1950E 05	0.7375E 05	24.6	0.2566E 05	0.1888E 06
12	0.8506E 04	0.5669E 05	0.1276E 06	15.0	0.2109E 05	0.8006E 05	24.4	0.2740E 05	0.2076E 06
13	0.9398E 04	0.6609E 05	0.1410E 06	15.0	0.2278E 05	0.8344E 05	23.9	0.2616E 05	0.2244E 06
14	0.1035E 05	0.7643E 05	0.1552E 06	15.0	0.2458E 05	0.8378E 05	23.1	0.2492E 05	0.2390E 06
15	0.1174E 05	0.8818E 05	0.1762E 06	15.0	0.3270E 05	0.7476E 05	21.4	0.2368E 05	0.2509E 06
16	0.1159E 05	0.9977E 05	0.1738E 06	15.0	0.9248E 04	0.8795E 05	22.6	0.2244E 05	0.2618E 06
17	0.1241E 05	0.1122E 06	0.1861E 06	15.0	0.2474E 05	0.8441E 05	21.8	0.2120E 05	0.2706E 06
18	0.1328E 05	0.1255E 06	0.1992E 06	15.0	0.2636E 05	0.7743E 05	20.8	0.1938E 05	0.2767E 06
19	0.1421E 05	0.1397E 06	0.2131E 06	15.0	0.2811E 05	0.6687E 05	19.7	0.1755E 05	0.2800E 06
20	0.1519E 05	0.1549E 06	0.2279E 06	15.0	0.2994E 05	0.5266E 05	18.5	0.1573E 05	0.2805E 06

YEAR	NET INV. PER TON ON DISC.R.	ANNUAL TOTAL NET INVESTMENT	ANNUAL INCOME	CUMULATIVE INVESTMENT	NEW INVESTMENT
	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $
				0.7176E 02	
1	1217.	0.1052E 02	0.0	0.8805E 02	0.1052E 02
2	1300.	0.1410E 02	0.3990E 00	0.1089E 03	0.1063E 02
3	1302.	0.1785E 02	0.2083E 02	0.1148E 03	0.1345E 02
4	1393.	0.2183E 02	0.2354E 02	0.1226E 03	0.1640E 02
5	1393.	0.2590E 02	0.2313E 02	0.1358E 03	0.1934E 02
6	1391.	0.2825E 02	0.2671E 02	0.1488E 03	0.2066E 02
7	1388.	0.3059E 02	0.2922E 02	0.1628E 03	0.2180E 02
8	1384.	0.3304E 02	0.3191E 02	0.1776E 03	0.2297E 02
9	1380.	0.3437E 02	0.3475E 02	0.1921E 03	0.2293E 02
10	1377.	0.3488E 02	0.3775E 02	0.2051E 03	0.2199E 02
11	1374.	0.3463E 02	0.4095E 02	0.2155E 03	0.2018E 02
12	1393.	0.3367E 02	0.4429E 02	0.2224E 03	0.1757E 02
13	1334.	0.3194E 02	0.4783E 02	0.2243E 03	0.1408E 02
14	1330.	0.2992E 02	0.5162E 02	0.2204E 03	0.1018E 02
15	1337.	0.2771E 02	0.6867E 02	0.1968E 03	0.5980E 01
16	1357.	0.2530E 02	0.1942E 02	0.2182E 03	0.6333E 00
17	1393.	0.2266E 02	0.5195E 02	0.2057E 03	-0.1679E 01
18	1278.	0.1976E 02	0.5536E 02	0.1859E 03	-0.6298E 01
19	1260.	0.1742E 02	0.5904E 02	0.1585E 03	-0.1048E 02
20	1247.	0.1519E 02	0.6287E 02	0.1230E 03	-0.1465E 02
	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $	$ $ $ $ $ $

TABLE OF EXPLORATION AREAS
****

TARGET DEPOSIT IS AVERAGE DEPOSIT
SIZE = 0.4000E 04 TONS METAL
GRADE= 0.1500E 04 PPM

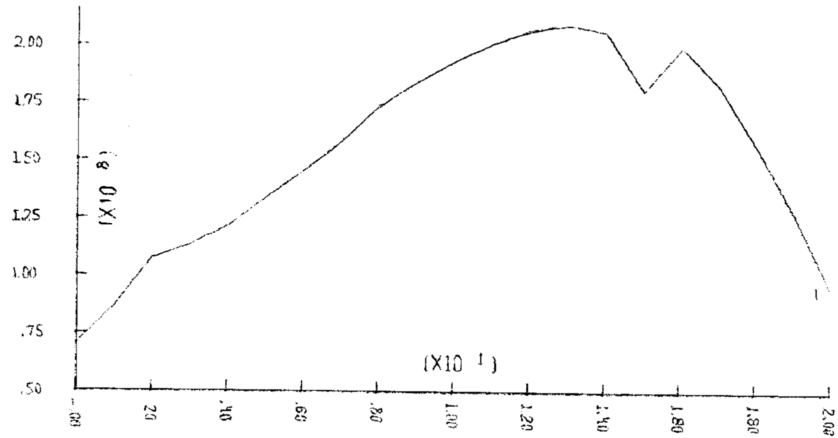
YEAR	ANNUAL DISCOVERY RATE	ANNUAL NET INVESTMENT $	EXPLORE SURFACE KM2	EXPL PRICE $/KM2	NUMBER OF DEPOSITS
1	4649.	10524775.	0.4558E 07	2.31	3.80
2	5544.	14104998.	0.5081E 07	2.78	4.23
3	6439.	17848352.	0.5604E 07	3.18	4.67
4	7334.	21825232.	0.6127E 07	3.56	5.11
5	15194.	25901552.	0.6650E 07	3.89	5.54
6	16938.	28253216.	0.7174E 07	3.94	5.98
7	18681.	30592400.	0.7697E 07	3.97	6.41
8	20425.	33041008.	0.8220E 07	4.02	6.85
9	22168.	34367136.	0.7848E 07	4.38	6.54
10	23912.	34878544.	0.7476E 07	4.67	6.23
11	25655.	34628416.	0.7104E 07	4.87	5.92
12	27399.	33670176.	0.6732E 07	5.00	5.61
13	26159.	31943504.	0.6360E 07	5.02	5.30
14	24920.	29917440.	0.5813E 07	5.15	4.84
15	23680.	27708528.	0.5266E 07	5.26	4.39
16	22441.	25295712.	0.4719E 07	5.36	3.93
17	21201.	22655504.	0.4172E 07	5.43	3.48
18	19377.	19763168.	0.3625E 07	5.45	3.02
19	17554.	17416560.	0.3078E 07	5.66	2.56
20	15730.	15191046.	0.2531E 07	6.00	2.11

TABLE OF EXPLORATION AREAS
****

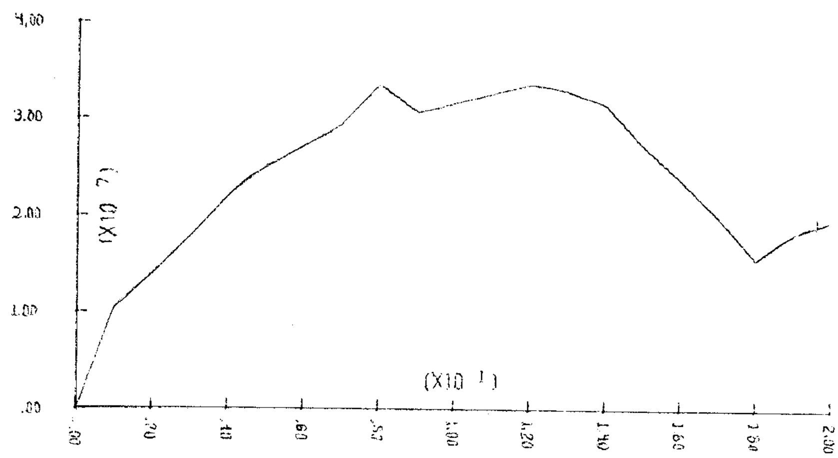
TARGET DEPOSITS ARE SPECIFIED

YEAR	ANNUAL DISCOVERY RATE	ANNUAL NET INVESTMENT $	TARGET DEPOSITS TONS METAL	GRADE	EXPLORE SURFACE KM2	EXPL PRICE $/KM2	NUMBER OF DEPOSITS	PROBABLE UNIT COST $/TON
1	4649.	10524775.	4000.	1500.	0.4537E 07	2.32	3.80	2090.
2	5544.	14104998.	4317.	1450.	0.4541E 07	3.11	3.92	2020.
3	6439.	17848352.	4660.	1402.	0.4501E 07	3.97	4.01	1954.
4	7334.	21825232.	5030.	1355.	0.4414E 07	4.94	4.06	1886.
5	15194.	25901552.	5429.	1310.	0.4303E 07	6.02	4.08	1823.
6	16938.	28253216.	5860.	1266.	0.4161E 07	6.79	4.08	1759.
7	18681.	30592400.	6325.	1224.	0.4009E 07	7.63	4.06	1700.
8	20425.	33041008.	6827.	1183.	0.3840E 07	8.61	4.01	1641.
9	22168.	34367136.	7369.	1144.	0.3295E 07	10.43	3.55	1587.
10	23912.	34878544.	7954.	1106.	0.2817E 07	12.38	3.13	1533.
11	25655.	34628416.	8585.	1069.	0.2400E 07	14.43	2.76	1480.
12	27399.	33670176.	9266.	1033.	0.2037E 07	16.53	2.42	1427.
13	26159.	31943504.	10001.	999.	0.1729E 07	18.47	2.12	1379.
14	24920.	29917440.	10795.	966.	0.1419E 07	21.08	1.80	1333.
15	23680.	27708528.	11652.	934.	0.1154E 07	24.01	1.51	1287.
16	22441.	25295712.	12577.	903.	0.9276E 06	27.27	1.25	1243.
17	21201.	22655504.	13575.	873.	0.7355E 06	30.80	1.02	1199.
18	19377.	19763168.	14652.	844.	0.5731E 06	34.48	0.82	1158.
19	17554.	17416560.	15815.	816.	0.4364E 06	39.91	0.65	1117.
20	15730.	15191046.	17070.	789.	0.3219E 06	47.19	0.49	1078.

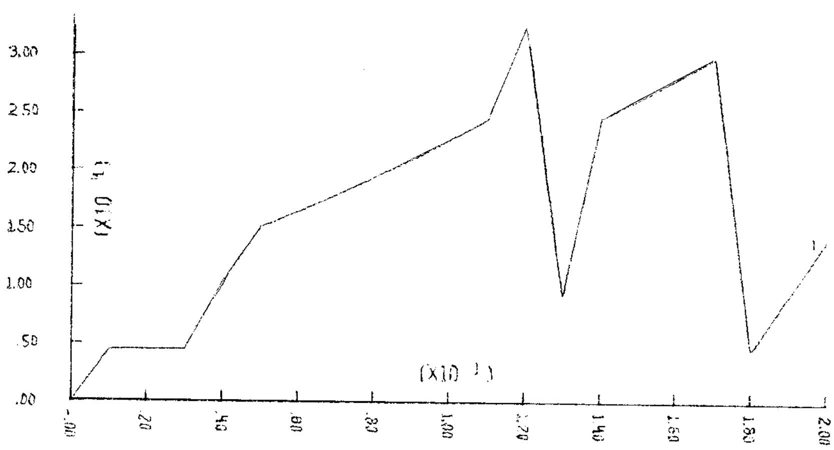
CUMULATIVE INVESTMENT



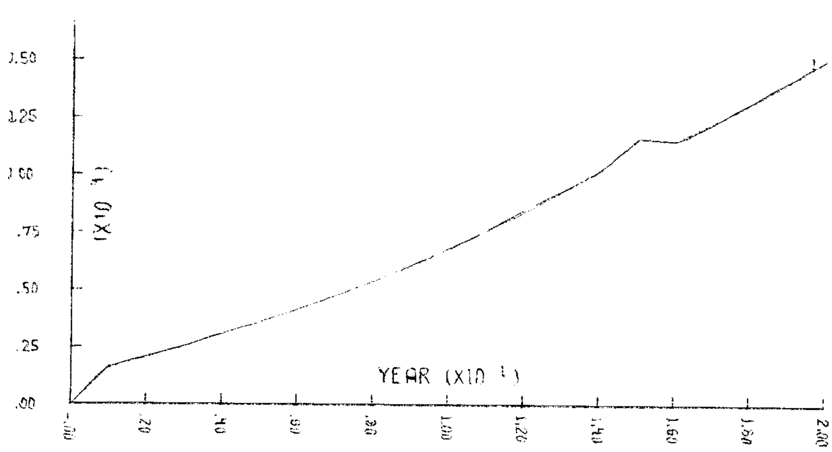
ANNUAL NET INVESTMENT



ANNUAL DISCOVERY RATE

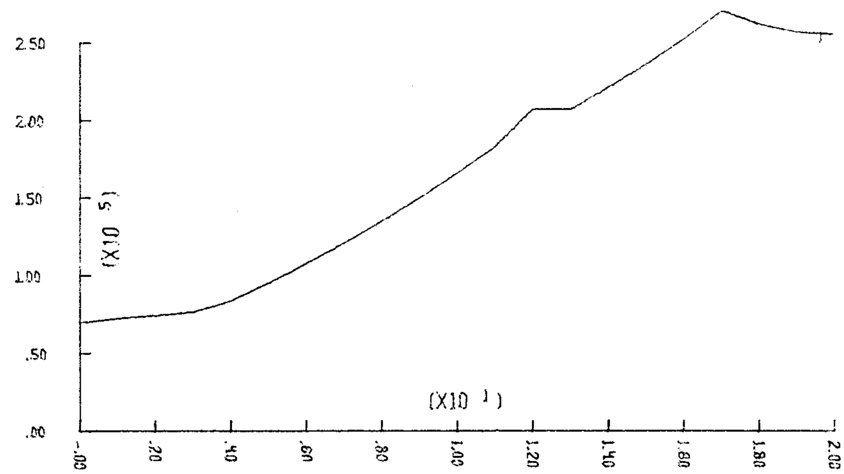


ANNUAL REQUIREMENTS



Graphical output; not leveled calculations

TOTAL RESERVES



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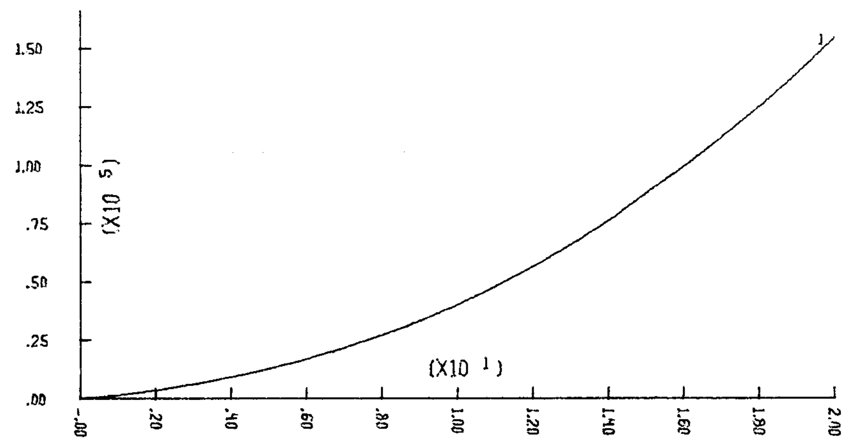
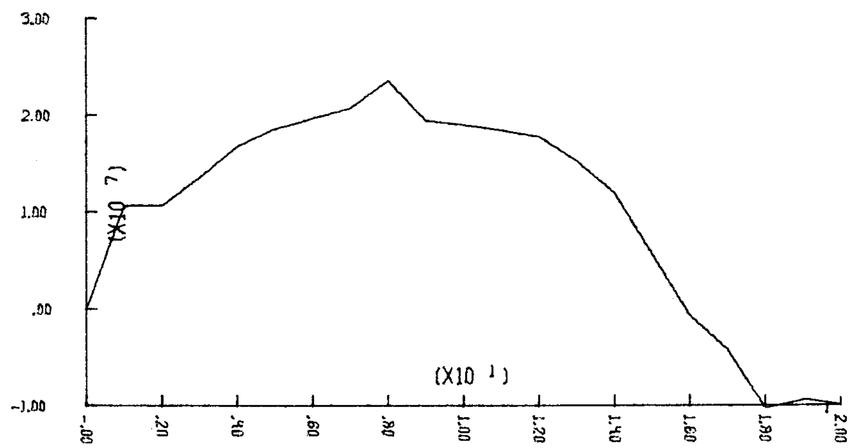
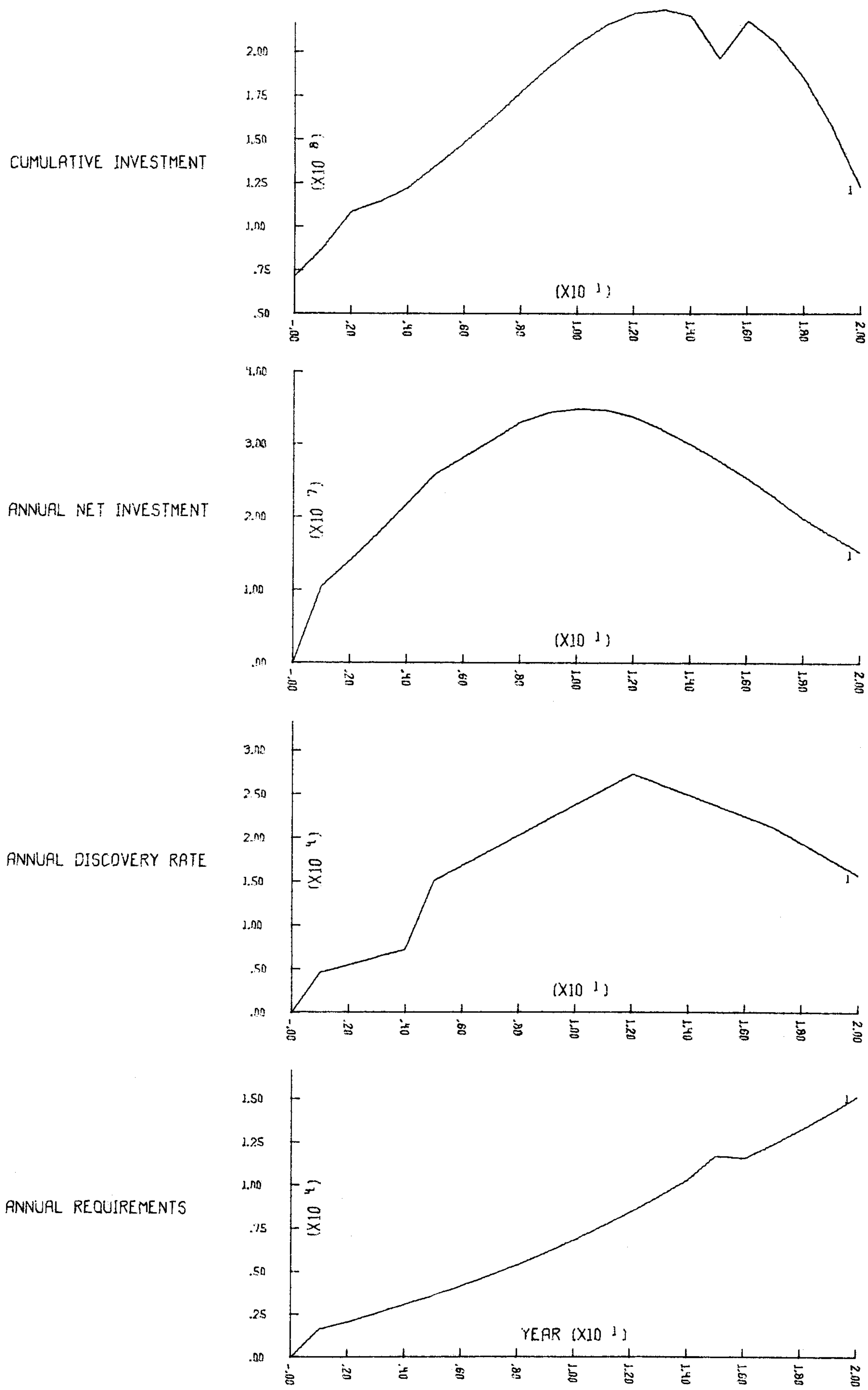


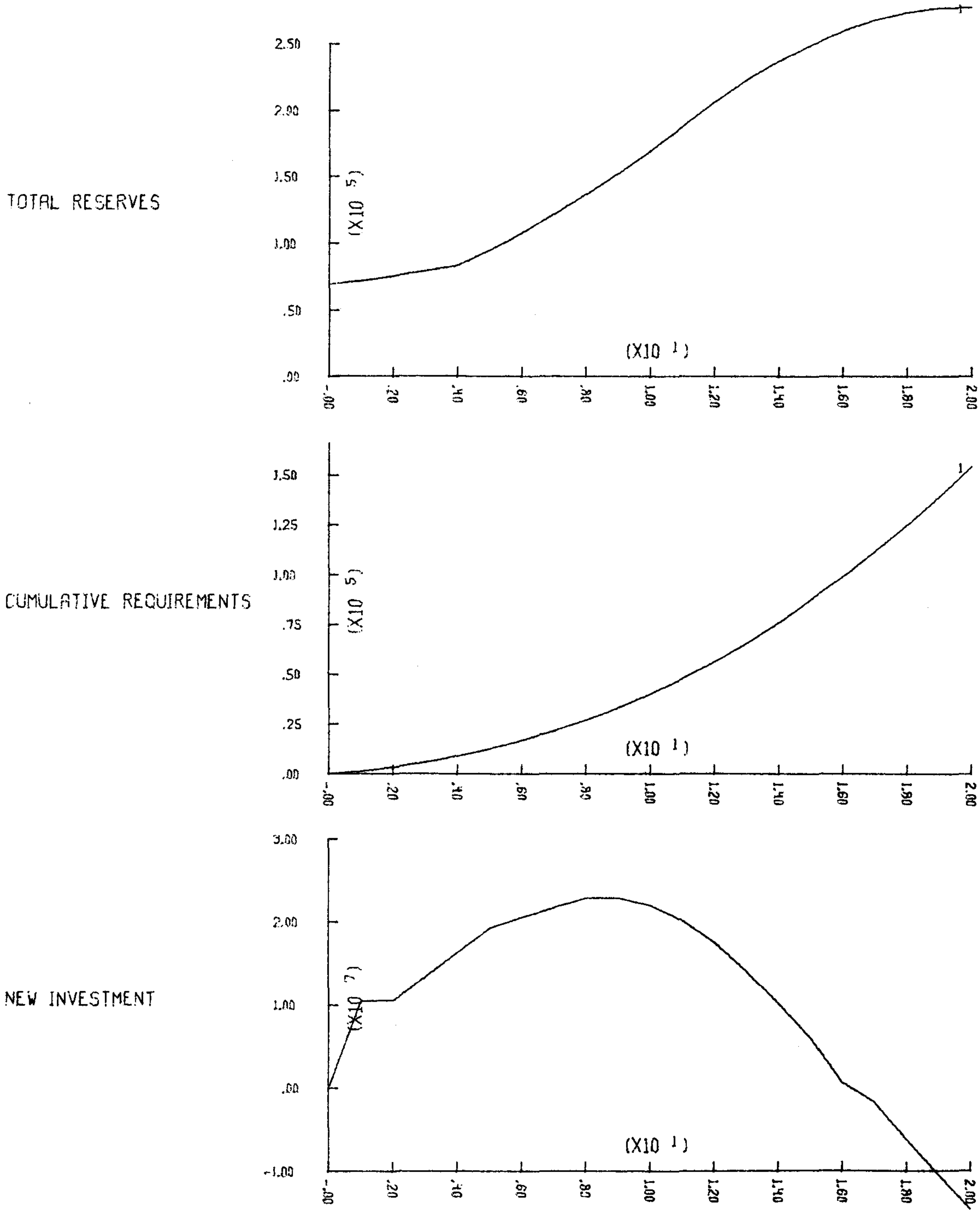
NEW INVESTMENT



Graphical output; not leveled calculations



Graphical output; leveled calculations



Graphical output; leveled calculations

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Alfred Nobel

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