EUR 4609 e

COMMISSION OF THE EUROPEAN COMMUNITIES

THE OPTIMIZATION OF MINERAL EXPLORATION INVESTMENTS WITH IMPOSED TARGETS BY THE PROGRAM EXIST

by

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

1971

Joint Nuclear Research Centre
Ispra Establishment - Italy
Scientific Data Processing Centre - CETIS
and
Directorate-General Energy

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1. A sufficient capitalized reserve must be always accessible
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3. The expenditures must be minimal while respecting the other conditions
4. Future adaptations of the definition of an exploitable deposit, imposed by the digestion of available reserves have to be incorporated.

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ABSTRACT

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KEYWORDS

COMPUTERS	PROSPECTING
PROGRAMMING	INVESTMENT
OPTIMIZATION	DEPOSITS
MINERALS	EXPLORATION
EXPLORATION	FORTRAN

Contents

INTRODUCTION *)

The program 'EXIST' is strongly related to the exploration investment optimization program 'EXILE'. Large parts of the both programs are identical and this paper refers accordingly many times to the already published 'EXILE' report.

The computer program 'EXIST' optimizes the mineral exploration investments according to the criterions:

1. A sufficient capitalized reserve must be always accessible
2. Strong variations in exploration activities must be avoided
3. The expenditures have to be minimal, respecting the other conditions
4. Future adaptions of the economic definition of an exploitable ore deposit, imposed by the digestion of available reserves, have to be forecasted and incorporated.

The major difference between 'EXILE' and 'EXIST' is given by the fourth criterion: 'EXIST' constructs a forecast on the development of the definition of an exploitable ore deposit. The name of the program has been derived accordingly from: Exploiration Investments by Size of Target. Large lower grade deposits will become exploitable in future as more and more metal is required and the present reserves are digested. 'EXIST' recognizes a size increase factor and a grade decrease factor which together define a development trend of the quality of the reserves. The time at which these larger lower grade deposits will be economicly exploitable depends on the consumption of the reserves. 'EXIST' calculates for each considered year a target deposit defined by a size and a grade. A secondary effect is the reduction of the unit exploration costs as larger deposits are easier to detect. This consequence is also quantitatively represented in 'EXIST'.

The next items are identical for 'EXILE' and 'EXIST':

1. The calculation of the stocktables
2. The capitalization scheme
3. The leveling procedure
4. The calculation of the probability of occurence of deposits of certain size and grade.

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*) Manuscript received on October 29, 1970

A brief description only of these items will be given in this paper since they have been described in full in the 'EXILE' report.

THE ANNUAL STOCKTABLE

The annual stocktable is calculated on the specified annual requirements, D_i, and the requested size of the capitalized reserves expressed as a multiple c on the annual requirements. The capitalized reserves M_i can be calculated by a recurrent relation starting from the capitalized reserve at time zero, M_o:

$$M_i = M_{i-1} - D_i \qquad \text{if} \qquad M_{i-1} - D_i \geq c \cdot D_i \qquad [1]$$

$$M_i = c \cdot D_i \qquad \text{if} \qquad M_{i-1} - D_i < c \cdot D_i \qquad [2]$$

in which i is the year index of the considered period.

The annual capitalized quantities V_i are:

$$V_i = M_i - M_{i+1} + D_i \qquad [3]$$

The annual non-capitalized reserves M'_i and the annual discovery rates M''_i are calculated according to:

$$\left.\begin{array}{l} M'_i = M''_{i-1} - V_i + M''_{min} \\ M''_i = M''_{min} \end{array}\right\} \text{if } M'_{i-1} - V_i \geq \sum_{j=i+1}^{i+i_p} V_j \qquad [4]$$

or:

$$\left.\begin{array}{l} M'_i = \sum_{j=i+1}^{i+i_p} V_j \\ M''_i = M'_i - M'_{i-1} + V_i \end{array}\right\} \text{if } M'_{i-1} - V_i < \sum_{j=i+1}^{i+i_p} V_j \qquad [5]$$

in which M''_{min} is a specified minimum discovery rate and i_p is the minimum time in years between the discovery of a deposit and its capitalization.

More details on the stocktable are given in the 'EXILE' report.

THE PROGNOSIS ON THE ORE QUALITY TREND

The definition of an exploitable ore deposit is related to the grade and to the total amount of metal in the deposit. Suppose that the total presently exploitable world reserves of a metal is r tons, occuring in deposits with an average grade of x PPM and an average size of z tons metal per deposit. Due to the digestion of the present reserves, in future lower grade deposits will become exploitable with a preference for the larger ones. The pattern of the definition development of the average ore deposit can be defined by two factors: a grade decrease factor F_x and a size increase factor F_z. So one may state that for uranium a potential reserve with a grade of 2/3 times the present median ore-grade should contain at least 2.5 times the amount of uranium. The time at which these potential reserves become available depends on the digestion of the present reserves. The characteristics of the target deposit for each year i are given by:

$$x_i = x \cdot F_x^{\frac{i}{t}} \text{ PPM} \qquad [6]$$

$$z_i = z \cdot F_z^{\frac{i}{t}} \text{ tons of metal per deposit} \qquad [7]$$

in which: x, z are the characteristics of present exploitable deposits

F_x, F_z are the specified grade decrease, respectively size increase factor

t is a factor with the dimension of years, depending on the digestion of the available reserves

The total reserves in the year i plus the already consumed metal until the year i are:

$$r_i = M_i + M_i' + [r - M_o - M_o'] + \sum_{j=1}^{i} D_j \text{ tons of metal} \qquad [8]$$

in which:

M_i is the capitalized reserve

M_i' is the non-capitalized reserve

$[r - M_o - M_o']$ is the cumulative consumption before time zero

r is the originally present quantity of metal of quality $[x,z]$

D_j are the annual requirements.

if now $r_i \leqslant r$, the target deposit specifications for the year i become:

$$x_i = x \quad \text{PPM}$$

$$z_i = z \quad \text{tons of metal per deposit} \qquad [9]$$

otherwise x_i and z_i must be calculated.

The appropriate x_i and z_i for a requested reserve r_i can be calculated by an iterative procedure. First a guess is made for x_i. Then the corresponding size z_i is given by:

$$z_i = \text{EXP}\left[\frac{\text{Log } F_z}{\text{Log } F_x} \cdot \text{Log } \frac{x_i}{x} + \text{Log } z\right] \text{ tons of metal} \qquad [10]$$

this expression is derived from the relations [6] and [7].
The following expressions are taken out of the theory on the Log-normal distributions of minerals as described in the 'EXILE' report. The linear equivalent of the deposit x_i, z_i can be expressed in the linear equivalent of the present average exploitable deposit x, z by:

$$_i = \sqrt[3]{\frac{x.z_i}{x_i.z}} \cdot d \quad \text{KM} \qquad [11]$$

Sequentially the next values are calculated:

$$\gamma_i = \frac{\bar{x}}{\text{EXP}\left[0.015 . \alpha . \text{Log } \frac{D}{d_i}\right]} \qquad [12]$$

$$\sigma_i = \sqrt{2 \text{ Log } \frac{\bar{x}}{\gamma_i}} \qquad [13]$$

$$P_i = 0.5 - 0.5 \text{ ERF}\left[\frac{\text{Log } \frac{x_i}{\gamma_i}}{\sqrt{2}.\sigma_i}\right] \qquad [14]$$

$$r_i = P_i.R.x_i.10^{-6} \quad \text{tons of metal} \qquad [15]$$

in which the next items are constant for a given metal:

$\bar{x}$ the average world grade in PPM

D the linear equivalent of the earth's crust = 24400 KM

R the total weight of the crust = 10^{18} tons

α the dispersion coefficient

The variables are:

γ_i the median grade of the collection of all samples of size $\frac{z_i}{x_i} \cdot 10^6$ tons

σ_i the standard deviation of the same collection

P_i the probability of occurence of deposits of quality $[x_i, z_i]$

r_i the total probable world reserves of quality $[x_i, z_i]$

The procedure given by the expressions [10] through [15] has to be repeated until a r_i is found equal to the requested reserves. The correspondong values of x_i and z_i are the specifications of the target deposit for the year i.

This approach can be justified by:

1. The development observed of mineral reserves with a long mining history;
2. The fact that the grade of the reserves on which the calculations are made is an average of substantially higher and lower grade ore deposits;
3. The systematic underestimation of the exploitable resources.

However, alternative solutions can be calculated by the program by specifying the target deposits for the consecutive years.

This alternative procedure should always be applied if programs of individual groups are studied (Community, company, etc.).

THE UNIT EXPLORATION COSTS

Supposing the considered metal presently has a market price of Q \$/ton of metal, A fraction a of this price may be spend on the exploration. Thus the present unit costs are:

$$U_o = a.Q.x.10^{-6} \text{ \$/ton of ore} \qquad [16]$$

in which x is the average grade of the present reserves. The unit costs for larger, lower grade deposits will be less as they are easier to detect. They are inversely proportional to their total number and their sizes. Once again the linear equivalent d_i is used to express the sizes. The unit costs become:

$$U_i = \frac{d.n}{d_i.n_i} \cdot a \cdot Q \cdot x \cdot 10^{-6} \text{ \$/ton of ore} \qquad [17]$$

in which d_i is the linear equivalent of the target deposit in year i

n_i is the total number of deposits in the earth's crust of the target deposit type

d and n are respectively the same constants for the present reserves

The calculation of d_i and n_i by means of the theory on the LOG-normal distributions, has been described in the 'EXILE' report. The unit exploration costs per ton of metal are:

$$T_i = \frac{d.n}{d_i.n_i} \cdot a \cdot Q \text{ \$/ton of metal} \qquad [18]$$

THE EXPLORATION INVESTMENTS

It is assumed that each year an equal amount of B_i \$ net will be invested during the exploration period of i_e years. These investments lead ultimately to the discovery of M''_i tons of metal in the year i. The gross investments in relation to M''_i, increase during i_e years according to:

year:	gross cumulative investment:	
1	$w_{i1} = B_i [1+k]$	
2	$w_{i2} = B_i [1+k] + B_i [1+k]^2$	
...	....	
i_e	$w_{ii_e} = B_i \sum_{j=1}^{i_e} [1+k]^j$	[19]

in which k is the interest rate.

The intrinsic value is estimated as w_{ii_e} \$ on the moment of discovery of the M''_i tons of metal. Afterwards the gross investments increase only with the interests until the year of capitalization i'_p with $i'_p \geq i_p$:

$$c_{M''_i} = [1+k]^{i'_p} \cdot B_i \cdot \sum_{j=1}^{i_e} [1+k]^j \qquad [20]$$

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 be calculated based on the principle "first in - first out".

The relations for the capitalization scheme are:

$$\begin{cases} v_{io} = V_i & \text{if } \left[M'_o - \sum_{j=1}^{i-1} v_{jo}\right] \geq V_i \\ v_{io} = M'_o - \sum_{j=1}^{i-1} v_{jo} & \text{if otherwise} \end{cases} \qquad [21]$$

$$v_{ij} = V_i - \sum_{k=o}^{j-1} v_{ik} \qquad \text{if } M''_j - \sum_{k-1}^{i} v_{k_j} \geq 0$$

$$v_{ij} = M''_j - \sum_{k=1}^{i-1} v_{kj} \qquad \text{if otherwise} \qquad [22]$$

in which: V_i is the annual capitalized quantity in tons of metal
v_{io} is the part of the original non capitalized reserve M'_o which will be capitalized in the year i
v_{ij} is the part of the quantity M''_j which is discovered in the year j and capitalized in the year i.

More details on the capitalization scheme and a numerical example are given in the 'EXILE' report.

The allowed gross investments per ton of metal on v_{ij} are T_i \$/ton as given in expression [18]. Thus:

$$\sum_{i=1}^{N} \frac{v_{ij} . T_i}{[1+k]^{i-j}} = B_j \cdot \sum_{l=1}^{i_e} [1+k]^l \qquad [23]$$

The annual net investments equal parts are thus:

$$B_j = \frac{1}{\sum_{l=1}^{i_e} [1+k]^l} \cdot \sum_{i=1}^{N} \frac{v_{ij} . T_i}{[1+k]^{i-j}} \qquad [24]$$

thus each year an amount of B_j \$ net may be invested to discover M''_j tons of metal in the year j.

With the previous expressions one may calculate the investments at time zero which are of two 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 investments on M'_o at capitalization time is:

$$C_{M'_o} = \sum_{i=1}^{N} v_{io} \cdot T_i \ \$ \qquad [25]$$

reduced to the time zero:

$$I'_{M'_o} = \sum_{i=1}^{N} \frac{v_{io} \cdot T_i}{[1+k]^i} \qquad [26]$$

The investments made before time zero on the doscoveries of the first i_e-1 years are based on the assumption that the net investments for a certain annual discovery are divided in i_e annual equal parts, B. As has been derived in the 'EXILE' report, the total investments on this type amount to:

$$I'_{M''_i} = \sum_{n=1}^{i_e-1} B_n \sum_{l=1}^{i_e-n} [1+k]^l \qquad [27]$$

Combining the expressions [26] and [27] the gross investments at time zero become:

$$I'_o = \sum_{i=1}^{N} \frac{v_{io} \cdot T_i}{[1+k]^i} + \sum_{n=1}^{i_e-1} B_n \sum_{l=1}^{i_e-n} [1+k]^l \qquad [28]$$

The total net investments in the year i are:

$$I_i = \sum_{j=i}^{i+i_e-1} B_j \qquad [29]$$

The annual gross proceeds are:

$$C_i = \sum_{j=1}^{N} v_{ij} \cdot T_j \qquad [30]$$

The new investments are defined as the total net investments in the year i minus the value of the produced metal in the previous year:

$$I'_i = I_i - D_{i-1} \cdot Y_{i-1} \qquad [31]$$

In which Y_i is the unit exploration cost of the capitalized reserve from which D_i is taken. However the capitalized reserve is composed of different types of ore which have been produced at different prices depending on the target deposit specifications. To calculate the unit costs of the capitalized reserve one must know the average grade of the reserve. Then one may calculate Y_i in \$/ton of metal by interpolation in the target grade versus unit costs table, according to the expressions [10] through [15] and [18].

At the end of the year i, the capitalized quantity of ore is:

$$\left[\frac{M_{i-1}-D_i}{G_{i-1}} + \sum_{j=0}^{N} \frac{v_{ij}}{x_j}\right] . 10^6 \text{ tons of ore} \qquad [32]$$

in which: G_i is the average grade of the capitalized reserve in the year i

v_{ij} is the quantity of metal discovered in the year j in deposits of average grade x_j PPM and capitalized in year i.

Thus the average grade G_i can be calculated by a recurrent relation as G_o is known:

$$G_i = \frac{M_i}{\left[\frac{M_{i-1}-D_i}{G_{i-1}} + \sum_{j=0}^{N} \frac{v_{ij}}{x_j}\right] . 10^6} \text{ PPM} \qquad [33]$$

The unit costs of the capitalized reserves are then:

$$Y_i = T_{i-1} + \frac{x_{i-1} - G_i}{x_i - x_{i-1}} . \left[T_i - T_{i-1}\right] \text{ \$/ton of metal} \qquad [34]$$

the new investments become:

$$I'_i = I_i - D_{i-1} . Y_{i-1} \qquad [35]$$

and the cumulative investments are:

$$\hat{I}_i = \left[\hat{I}_{i-1} + I_i\right] . \left[1+k\right] - C_i \qquad [36]$$

in which $\hat{I}_o = I'_o$, the gross zero time investments.

INPUT DESCRIPTION

SYMBOL	FORTRAN NAMES	RELATED EXPRESSIONS	
I_1	IND(1)		not used
I_2	IND(2)	INPUT	= 0 the target deposits are specified by their grades
		[10]-[15]	= 1 the target deposits will be calculated [only permitted in relation with world requirements]
I_3	IND(3)		Significant only if I_2 = 1 = 0 the target deposits will be calculated once = 1 the target deposits will be redefined with each leveling request
I_4	IND(4)	'EXILE'	= 1 perform also the levelling
I_5	IND(5)		= 1 graphical output required according to the next specifications
K_i	IGRAPH(i)		The numbers of the requested curves:
		D_i	= 1 annual requirements
		M''_i; [4]	= 1 annual discovery rates
		M'_i; [4]	= 3 non capitalized reserves
		M_i; [1]	= 4 capitalized reserves
		V_i; [3]	= 5 annual capitalization
		I_i; [29]	= 6 annual net investments
		C_i; [30]	= 7 annual gross proceeds
		I_i; [36]	= 8 cumulative investments
K_i	IGRAPH(i)	I'_i; [35]	= 9 new investments
		$\sum D_i$	= 14 cumulative requirements
		$M_i+M'_i$	= 15 total reserves
r	RSMALL	[8]	Tons of metal total presently exploitable world reserves plus already consumed metal

SYMBOL	FORTRAN NAMES	RELATED EXPRESSIONS	
z	ZA	[7]	Tons of metal average ore deposit
x_r	XRSM	[6]	PPM average grade of the world reserves
F_z	FZZ	[7]	Size increase factor
F_x	FXX	[6]	Grade decrease factor
$\bar{x}$	XENY	[12]	PPM average grade of the earth's crust
ρ	RHO	EXILE	Specific gravity of the ore
b/a	BDA	EXILE	Dimension ratios of the average
c/b	CBD	EXILE	Deposit with $a \geq b \gg c \neq 0$
N_y	NYEAR		Number of years of the considered period
i_e	IE		Average number of years between the start of an exploration and the evidence of a deposit
i_p	IP		Minimum number of years between the discovery of a deposit and its capitalization
M_o	EMO	[1] [2]	Initial capitalized reserves in tons of metal
M'_o	EMAO	[4] [5]	Initial non-capitalized reserves
M''_{min}	EMAAO	[4] [5]	Minimum annual discovery rate
Q	Q	[16]	Market price in $/ton of metal
c	CRATIO	[2]	Required ratio capitalized reserves/annual requirements
a	ARATIO	[16]	Allowed exploration costs as a fraction on the market price
θ	FINTER	[19]	Interest rate as a fraction on 1
x_i	XTAR(i)	[10] - [15]	Only if $I_2 = 0$, grades of the target deposits
d_i	D(i)	[1] [2]	Annual requirements in tons of metal

SYMBOL	FORTRAN NAMES	RELATED EXPRESSIONS	
L	NLEV	EXILE	Only if $I_4 > 0$ = 0 only an automatic leveling is performed > 0 L preference direction coefficients follow; each of them gives raise to an independent leveling
a_i	ALE(i)	EXILE	Only if L > 0 : preference direction coefficients for the first interval after the initial period of i_e years

CETIS/CADI (EURATOM)

PROBLEM : INPUT SYMBOLS FOR 'EXIST' | DATE | PAGE OF

1	T I T L E	
2	I_1 I_2 I_3 I_4 I_5 k_1 k_2 k_3	*)
3	η z x_4 F_z F_x	
4	$\bar{x}$ ρ b/a c/b	
5	N_γ i_e i_p	*)
6	M_0 M'_0 M''_{MIN}	
7	Q	
8	c a ν	
9–10 (ONLY IF $I_2 \neq 0$)	x_1 x_2 x_3 ... x_N	
11–12 (ONLY IF $L > 0$)	d_1 d_2 d_3 ... d_N	
13	L	*)
14 (ONLY IF $L > 0$)	a_1 a_2 ... a_L	

*) FIXED POINT DATA
[A FIXED POINT NUMBER HAS TO BE WRITTEN UTMOST RIGHT IN ITS FIELD WITHOUT A DECIMAL PERIOD]

CETIS/CADI (EURATOM)

PROBLEM: INPUT EXIST | DATE | PAGE | OF

	1–12	13–24	25–36	37–48	49–60	61–72
1	← T I T L E					→
2	I_1 I_2	I_3 I_4	I_5	K_1 K_2	K_3 – – –	– – – –
3	η	Z	X_η	F_z	F_x	
4	$\bar{X}$	ρ	b/a	c/b		
5	N_y i_e	i_p				
6	M_0	M'_0	M''_{MIN}			
7	Q					
8	c	a	ϑ			
9 (IF $I_2 = 0$ →)	X_1	X_2	X_3 – – –	– – –	– – –	– – –
10	– – –	– – –	– –	X_N		
11	d_1	d_2	d_3 – – –	– – –	– – –	– – –
12	– – –	– – –	– –	d_N		
13	L					
14 (IF $L > 0$ →)	a_1	a_2 – –	– – –	– – –	a_L	

PROBLEM INPUT EXAMPLE 'EXIST'   DATE   PAGE   OF

```
'EXIST'  WØRLD LØW URANIUM REQUIREMENTS 1970-1992
           1     1     1     1              1  2  6  9
    7.2  E+5    4.0  E+3    1.65 E+3    2.5         0.6667
    3.0         2.7         0.5         0.1
    22     5     3
    3.5  E+5    1.0  E+5    5.0  E+4
    2.1  E+4
   15.0         0.1         0.08
 17320.      18090.      21560.      25790.      29680.      33880.
 38500.      42350.      46970.      52360.      56210.      58330.
 62850.      67500.      72270.      77170.      82220.      87410.
 92750.      98250.     103900.     109820.
     0
```


VI - CET 002

INPUT DATA
****

'EXIST' WORLD LOW URANIUM REQUIREMENTS 1970-1992

TOTAL WORLD RESERVES	0.7200E 06	TONS METAL
AVERAGE ORE DEPOSIT	0.4000E 04	TONS METAL
AVERAGE GRADE RESERVES	0.1650E 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)	0.1577E 01	PPM
ALFA (CALCULATED)	0.3981E 01	PERCENT
TOTAL TIME	22	YEARS
EXPLORATION UNTIL DISCOVERY	5	YEARS
CAPITALIZATION TIME	3	YEARS
MINIMUM ANNUAL EXPLORATION	0.5000E 05	TONS METAL
PRICE OF CAPITALIZED PRODUCT	0.2100E 05	$
EXPLORATION FRACTION OF PRICE	0.1000E 00	
RESERVES / ANNUAL CONSUMPTION	0.1500E 02	
INTEREST RATE	0.8000E 01	PERCENT

NON-LEVELED STOCKTABLE
****

'EXIST' WORLD LOW URANIUM REQUIREMENTS 1970-1992

YEAR	ANNUAL REQUIREMENT	CUMULATIVE REQUIREMENT	CUMULATIVE CAPITALIZED RESERVES	RATIO CAP. RES.	CAPITALIZED ANNUAL	CUM. NOT CAPITALIZED RESERVES	RATIO TOTAL RES.	ANNUAL DISCOVERY RATE
		0.2700E 06	0.3500E 06			0.1000E 06		
1	0.1732E 05	0.2873E 06	0.3327E 06	19.2	0.0	0.1500E 06	27.9	0.5000E 05
2	0.1809E 05	0.3054E 06	0.3146E 06	17.4	0.0	0.2076E 06	28.9	0.5764E 05
3	0.2156E 05	0.3270E 06	0.3234E 06	15.0	0.3037E 05	0.2741E 06	27.7	0.9688E 05
4	0.2579E 05	0.3528E 06	0.3868E 06	15.0	0.8924E 05	0.2927E 06	26.3	0.1078E 06
5	0.2968E 05	0.3824E 06	0.4452E 06	15.0	0.8803E 05	0.3048E 06	25.3	0.1001E 06
6	0.3388E 05	0.4163E 06	0.5082E 06	15.0	0.9688E 05	0.3242E 06	24.6	0.1163E 06
7	0.3850E 05	0.4548E 06	0.5775E 06	15.0	0.1078E 06	0.3496E 06	24.1	0.1332E 06
8	0.4235E 05	0.4972E 06	0.6352E 06	15.0	0.1001E 06	0.3634E 06	23.6	0.1140E 06
9	0.4697E 05	0.5441E 06	0.7045E 06	15.0	0.1163E 06	0.3373E 06	22.2	0.9013E 05
10	0.5236E 05	0.5965E 06	0.7854E 06	15.0	0.1332E 06	0.3347E 06	21.4	0.1306E 06
11	0.5621E 05	0.6527E 06	0.8431E 06	15.0	0.1140E 06	0.3580E 06	21.4	0.1372E 06
12	0.5833E 05	0.7110E 06	0.8749E 06	15.0	0.9013E 05	0.4117E 06	22.1	0.1438E 06
13	0.6285E 05	0.7739E 06	0.9427E 06	15.0	0.1306E 06	0.4317E 06	21.9	0.1507E 06
14	0.6750E 05	0.8414E 06	0.1012E 07	15.0	0.1372E 06	0.4525E 06	21.7	0.1580E 06
15	0.7227E 05	0.9137E 06	0.1084E 07	15.0	0.1438E 06	0.4739E 06	21.6	0.1653E 06
16	0.7717E 05	0.9908E 06	0.1158E 07	15.0	0.1507E 06	0.4961E 06	21.4	0.1728E 06
17	0.8222E 05	0.1073E 07	0.1233E 07	15.0	0.1580E 06	0.5189E 06	21.3	0.1807E 06
18	0.8741E 05	0.1160E 07	0.1311E 07	15.0	0.1653E 06	0.5422E 06	21.2	0.1886E 06
19	0.9275E 05	0.1253E 07	0.1391E 07	15.0	0.1728E 06	0.5677E 06	21.1	0.1983E 06
20	0.9825E 05	0.1351E 07	0.1474E 07	15.0	0.1807E 06	0.4369E 06	19.4	0.5000E 05
21	0.1039E 06	0.1455E 07	0.1558E 07	15.0	0.1886E 06	0.3190E 06	18.1	0.7071E 05
22	0.1098E 06	0.1565E 07	0.1647E 07	15.0	0.1983E 06	0.2247E 06	17.0	0.1040E 06

TABLE OF INVESTMENTS
****

'EXIST' WORLD LOW URANIUM REQUIREMENTS 1970-1992

YEAR	TARGET DEPOSIT TONS METAL	GRADE PPM	PROD. UNIT COSTS $/TON OF ORE	$/TON OF METAL	DISC. RATE TONS	TOT.NET INVESTM. M$	RETURN BY CAP. M$	NEW INVESTM. M$	CUM. INVESTM. M$	AV.GRADE CAP.RES. M$
									318.3	
1	4190.	1616.	3.32	2053.	50000.	90.8	0.0	55.2	441.9	1650.
2	4421.	1579.	3.13	2012.	57640.	104.0	0.0	68.4	589.5	1650.
3	4800.	1522.	2.97	1949.	96880.	117.9	62.4	80.8	701.7	1650.
4	5208.	1468.	2.77	1838.	107800.	119.0	182.4	74.7	703.9	1648.
5	5578.	1424.	2.62	1838.	100100.	113.2	173.5	60.2	709.0	1637.
6	5997.	1379.	2.47	1787.	116270.	116.9	182.9	55.8	709.0	1614.
7	6463.	1334.	2.32	1736.	133210.	118.3	198.2	47.5	695.3	1584.
8	6853.	1300.	2.21	1696.	113960.	117.5	178.9	39.1	698.8	1557.
9	7137.	1277.	2.13	1669.	90130.	121.8	201.8	34.1	684.5	1524.
10	7585.	1243.	2.03	1630.	130650.	132.1	226.0	38.8	656.0	1488.
11	8027.	1212.	1.93	1594.	137280.	135.7	190.2	36.4	664.8	1460.
12	8481.	1183.	1.84	1559.	143020.	139.4	146.9	31.4	721.6	1439.
13	8947.	1155.	1.76	1526.	150670.	143.6	208.2	35.2	726.1	1408.
14	9424.	1129.	1.69	1495.	157970.	148.1	214.0	35.7	730.2	1378.
15	9918.	1104.	1.62	1465.	165260.	153.3	219.5	30.3	734.7	1348.
16	10423.	1080.	1.55	1436.	172850.	132.5	225.3	5.8	711.2	1320.
17	10940.	1057.	1.49	1408.	180750.	114.7	231.4	-17.0	660.6	1292.
18	11470.	1035.	1.43	1382.	188650.	101.0	237.3	-37.5	585.2	1265.
19	12004.	1015.	1.38	1357.	198300.	86.0	243.4	-56.9	481.5	1238.
20	12156.	1009.	1.36	1350.	50000.	69.6	249.8	-84.8	345.4	1213.
21	12348.	1002.	1.34	1341.	70715.	78.4	256.0	-81.0	201.7	1188.
22	12622.	992.	1.32	1330.	103983.	83.3	267.7	-81.0	40.2	1164.

LEVELED STOCKTABLE
****

'EXIST' WORLD LOW URANIUM REQUIREMENTS 1970-1992

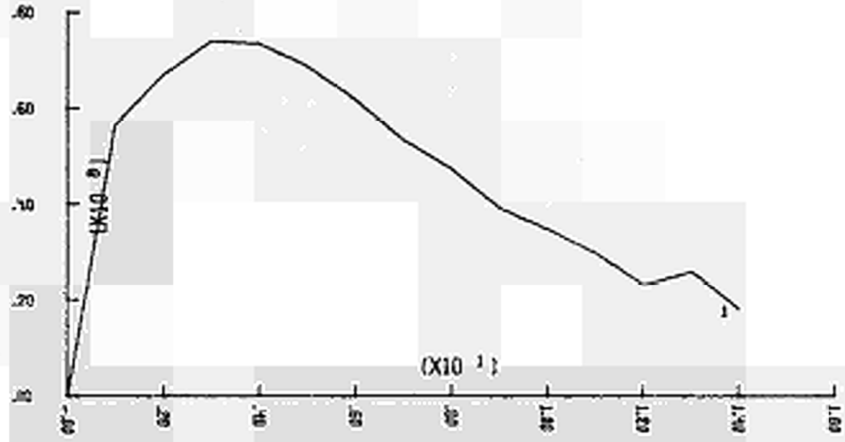
YEAR	ANNUAL REQUIREMENT	CUMULATIVE REQUIREMENT	CUMULATIVE CAPITALIZED RESERVES	RATIO CAP. RES.	CAPITALIZED ANNUAL	CUM. NOT CAPITALIZED RESERVES	RATIO TOTAL RES.	ANNUAL DISCOVERY RATE
		0.2700E 06	0.3500E 06			0.1000E 06		
1	0.1732E 05	0.2873E 06	0.3327E 06	19.2	0.0	0.1621E 06	28.6	0.6213E 05
2	0.1809E 05	0.3054E 06	0.3146E 06	17.4	0.0	0.2349E 06	30.4	0.7276E 05
3	0.2156E 05	0.3270E 06	0.3234E 06	15.0	0.3037E 05	0.2879E 06	28.4	0.8340E 05
4	0.2579E 05	0.3528E 06	0.3868E 06	15.0	0.8924E 05	0.2927E 06	26.3	0.9403E 05
5	0.2968E 05	0.3824E 06	0.4452E 06	15.0	0.8803E 05	0.3172E 06	25.7	0.1125E 06
6	0.3388E 05	0.4163E 06	0.5082E 06	15.0	0.9688E 05	0.3375E 06	25.0	0.1172E 06
7	0.3850E 05	0.4548E 06	0.5775E 06	15.0	0.1078E 06	0.3515E 06	24.1	0.1219E 06
8	0.4235E 05	0.4972E 06	0.6352E 06	15.0	0.1001E 06	0.3780E 06	23.9	0.1266E 06
9	0.4697E 05	0.5441E 06	0.7045E 06	15.0	0.1163E 06	0.3930E 06	23.4	0.1313E 06
10	0.5236E 05	0.5965E 06	0.7854E 06	15.0	0.1332E 06	0.3957E 06	22.6	0.1359E 06
11	0.5621E 05	0.6527E 06	0.8431E 06	15.0	0.1140E 06	0.4224E 06	22.5	0.1406E 06
12	0.5833E 05	0.7110E 06	0.8749E 06	15.0	0.9013E 05	0.4776E 06	23.2	0.1453E 06
13	0.6265E 05	0.7739E 06	0.9427E 06	15.0	0.1306E 06	0.4969E 06	22.9	0.1500E 06
14	0.6750E 05	0.8414E 06	0.1012E 07	15.0	0.1372E 06	0.5144E 06	22.6	0.1547E 06
15	0.7227E 05	0.9137E 06	0.1084E 07	15.0	0.1438E 06	0.5300E 06	22.3	0.1594E 06
16	0.7717E 05	0.9908E 06	0.1158E 07	15.0	0.1507E 06	0.5434E 06	22.0	0.1641E 06
17	0.8222E 05	0.1073E 07	0.1233E 07	15.0	0.1580E 06	0.5542E 06	21.7	0.1688E 06
18	0.8741E 05	0.1160E 07	0.1311E 07	15.0	0.1653E 06	0.5624E 06	21.4	0.1735E 06
19	0.9275E 05	0.1253E 07	0.1391E 07	15.0	0.1728E 06	0.5677E 06	21.1	0.1782E 06
20	0.9825E 05	0.1351E 07	0.1474E 07	15.0	0.1807E 06	0.5490E 06	20.6	0.1620E 06
21	0.1039E 06	0.1455E 07	0.1558E 07	15.0	0.1886E 06	0.5062E 06	19.9	0.1459E 06
22	0.1098E 06	0.1565E 07	0.1647E 07	15.0	0.1983E 06	0.4376E 06	19.0	0.1297E 06

TABLE OF INVESTMENTS
****

'EXIST' WORLD LOW URANIUM REQUIREMENTS 1970-1992

YEAR	TARGET DEPOSIT TONS METAL	GRADE PPM	PROB. UNIT COSTS $/TON OF ORE	$/TON OF METAL	DISC. RATE TONS	TOT.NET INVESTM. M$	RETURN BY CAP. M$	NEW INVESTM. M$	CUM. INVESTM. M$	AV.GRADE CAP.RES. M$
									329.6	
1	4239.	1608.	3.29	2044.	62132.	92.1	0.0	56.7	455.4	1650.
2	4529.	1562.	3.11	1993.	72764.	102.5	0.0	67.1	602.6	1650.
3	4852.	1515.	2.94	1941.	83396.	111.0	62.1	74.0	708.6	1650.
4	5208.	1468.	2.77	1888.	94028.	117.4	181.4	73.4	710.6	1648.
5	5623.	1419.	2.60	1833.	112490.	121.4	173.1	68.7	725.5	1635.
6	6044.	1375.	2.45	1782.	117181.	122.5	184.3	61.8	731.6	1613.
7	6470.	1334.	2.31	1735.	121871.	123.5	198.3	53.4	725.1	1585.
8	6895.	1297.	2.19	1692.	126561.	124.3	178.4	47.4	739.1	1557.
9	7285.	1266.	2.10	1656.	131252.	125.4	202.3	39.2	731.3	1524.
10	7783.	1229.	1.98	1613.	135942.	127.2	226.0	34.7	701.1	1489.
11	8232.	1199.	1.89	1578.	140632.	129.2	188.8	29.8	707.9	1460.
12	8676.	1171.	1.81	1545.	145323.	131.3	146.0	23.3	760.4	1438.
13	9146.	1144.	1.73	1513.	150013.	133.7	208.1	26.1	757.5	1407.
14	9612.	1119.	1.66	1483.	154703.	136.3	214.1	18.2	751.3	1377.
15	10077.	1096.	1.60	1456.	159394.	139.3	219.7	16.9	742.1	1348.
16	10556.	1074.	1.53	1429.	164084.	136.5	225.5	9.9	723.4	1320.
17	11041.	1053.	1.48	1403.	168774.	129.9	231.8	-1.1	689.8	1292.
18	11528.	1033.	1.42	1379.	173465.	119.9	237.8	-16.3	636.7	1265.
19	12004.	1015.	1.38	1357.	178155.	106.8	244.0	-40.7	559.0	1239.
20	12360.	1002.	1.34	1341.	162017.	90.8	250.4	-60.6	451.3	1213.
21	12853.	984.	1.30	1320.	145879.	77.9	256.8	-78.3	314.8	1189.
22	13197.	973.	1.27	1306.	129742.	59.4	266.2	-102.0	137.9	1165.

NEW INVESTMENT



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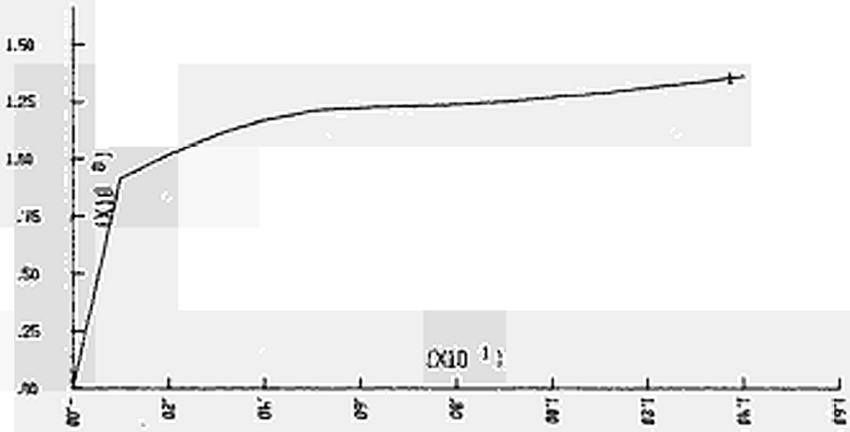
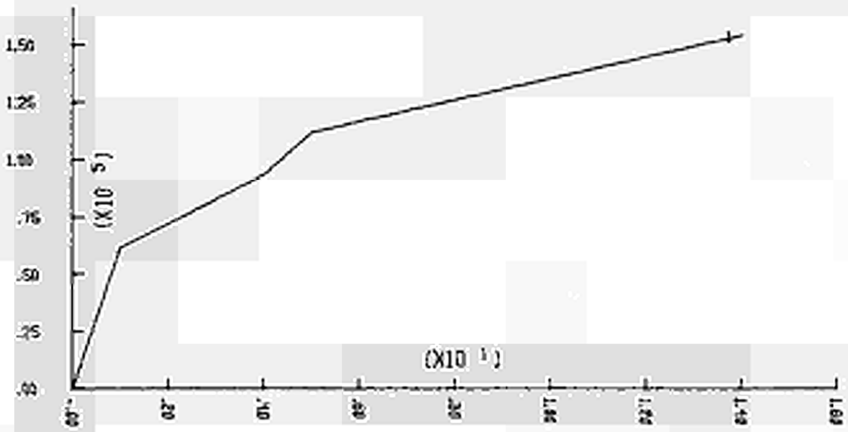
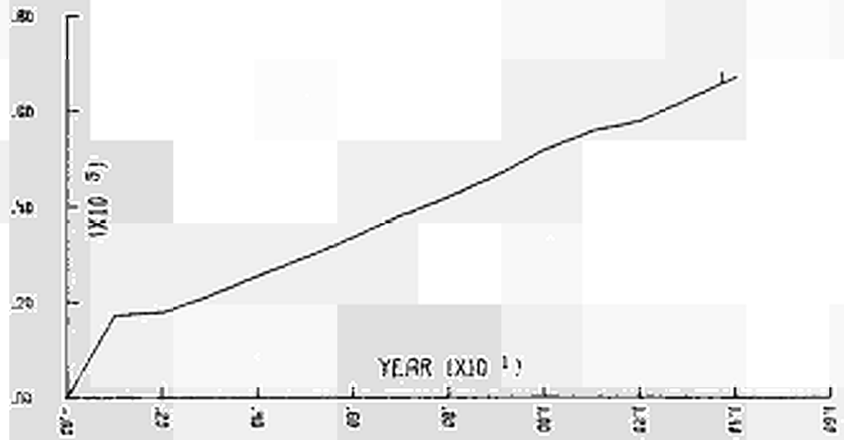


ANNUAL DISCOVERY RATE



ANNUAL REQUIREMENTS



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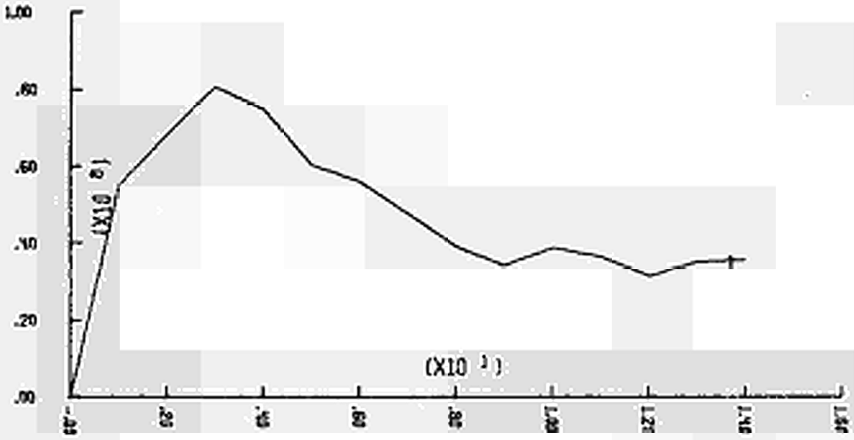

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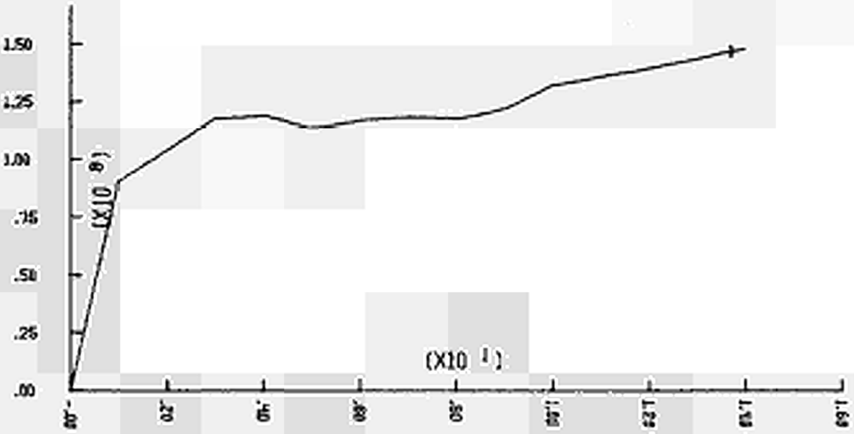

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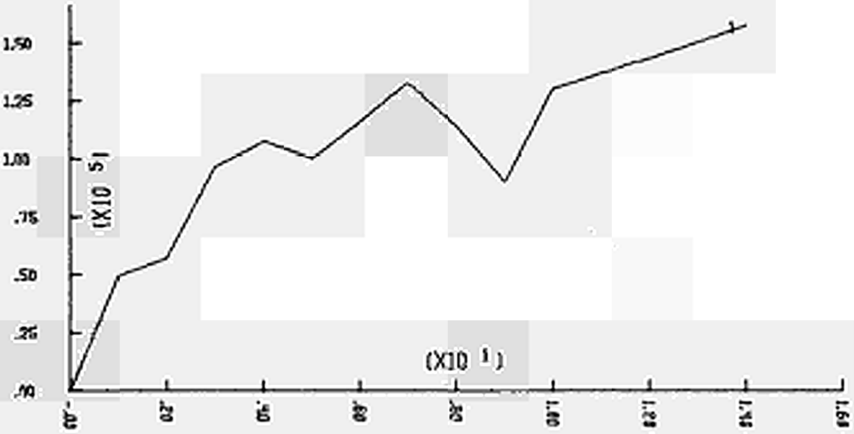

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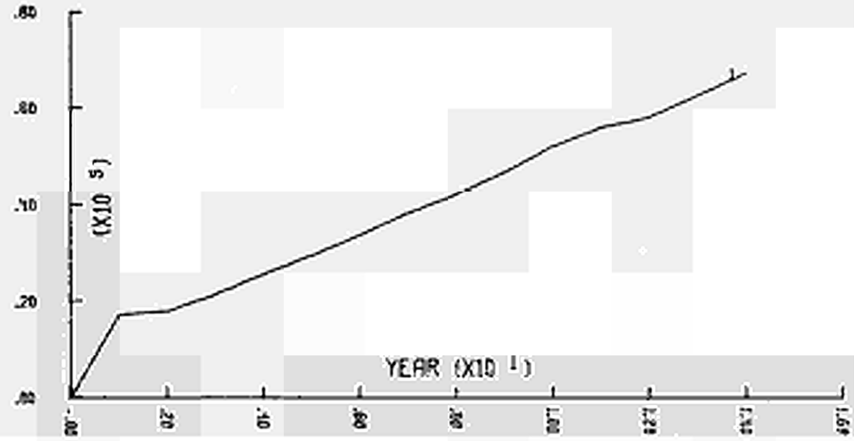

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C-----PROGRAM EXIST BY HERMAN I. DE WOLDE CETIS-EURATOM FEBRUARY 1970---
C
C     EXPLORATION INVESTMENT BY SIZE OF TARGET
C
C             EXIST OPTIMIZES THE RAW MATERIALS INVESTMENTS
C             WITH RESPECT TO THE CRITERIONS
C             1. A SUFFICIENT CAPITALIZED RESERVE, IN RELATION TO THE
C                ANNUAL NEEDS, MUST BE ACCESSIBLE AT ANY MOMENT
C             2. SHOCK EFFECTS DUE TO CONSUMPTION VARIATIONS MUST BE
C                LEVELED SMOOTHLY
C             3. LARGER, LOWER GRADE DEPOSITS ARE CHEAPER TO DISCOVER.
C                IF THEY BECOME EXPLOITABLE THE REQUESTED
C                INVESTMENTS DECREASE.
C             4. MINIMAL COSTS
C
C
C
C
C
C
C
      DIMENSION D(50),EM(50),EMA(50),DINV(50),EMAA(50)
      DIMENSION ACDINV(50),DEP(50),S(50),B(50)
      DIMENSION V(50),W(50,20),C(50),DINGR(50),BB(50)
      DIMENSION IND(8),ANDEP(50),ILL(50)
      DIMENSION VSMALL(50,50),TOTREQ(50)
      DIMENSION RES(10),TOTR(50)
      DIMENSION EMAAN(50),ALE(12),HELP(50)
      DIMENSION X(50),Y(50),IGRAPH(10)
      DIMENSION ITAR(50),RTAR(50),XTAR(50)
      DIMENSION G(50),U(50),T(50),DEV(3,50),TG(50)
      DIMENSION TIT(18)
      COMMON XRSM,ZA,RSMALL,ALFA,DSMALL,FXX,FZZ,XENV,CUMREQ
C
C-----BASIC INFORMATION ON THE OCCURENCE OF THE MINERAL
C
      READ (5,98) (TIT(I),I=1,18)
   98 FORMAT (18A4)
   99 FORMAT (/1H ,18A4/)
      READ (5,101) (IND(I),I=1,7),(IGRAPH(I),I=1,10)
  101 FORMAT (7I6,10I3)
      NGRAPH=0
      IF (IND(5).EQ.0) GO TO1105
      DO 103 I=1,10
      IF (IGRAPH(I).EQ.0) GO TO1105
      NGRAPH=NGRAPH+1
  103 CONTINUE
 1105 CONTINUE
  102 FORMAT (12I6)
      READ (5,104) RSMALL,Z,XRSM,FZZ,FXX
```

```
  104 FORMAT (6E12.4)
      ZA=Z
      Z=Z*1.E+6/XRSM
C
C-----WRITE INPUT DATA
C
      WRITE (6,114)
  114 FORMAT (1H1/' INPUT DATA'/' **********'//)
      WRITE (6,99) (TIT(I),I=1,18)
      WRITE (6,116) RSMALL,ZA,XRSM
  116 FORMAT(/' TOTAL WORLD RESERVES',9X,E12.4,' TONS METAL'//
     1' AVERAGE ORE DEPOSIT',10X,E12.4,' TONS METAL'//
     2' AVERAGE GRADE RESERVES',7X,E12.4,' PPM'/)
      READ (5,104) XENV,RHO,BDA,CDB
C
C-----CALCULATE ALFA AND GAMMA----------------------------------------
C
      F=(Z*1.E-9)/RHO
      A=(F/(BDA**2*CDB))**0.333333
      DSMALL=A*(1.+BDA*(1+CDB))
      JA=1
      P=(RSMALL*1.E-12)/XRSM
      CALL PNP (P,ENP,JA)
C
      ENP=ENP/SQRT(2.□
      GAMENV=    (-4.*ENP**2+2.*ALOG(XRSM)+4.*ENP*
     1SQRT(ENP**2-ALOG(XRSM)+ALOG(XENV)))
      GAMENV=EXP(GAMENV/2.)
      ALFA=100.*(ALOG(XRSM/GAMENV))**2/(6.*ALOG(24400./DSMALL)*ENP**2)
      WRITE (6,118) XENV,RHO,BDA,CDB,GAMENV,ALFA
  118 FORMAT (' AVERAGE CONTENT IN CRUST',5X,E12.4,' PPM'//
     1' SPECIFIC GRAVITY',13X,E12.4,' GR/CM3'//
     2' DIMENSION RATIO B/A',10X,E12.4//
     3' DIMENSION RATIO C/B',10X,E12.4//
     4' GAMMA (CALCULATED)',11X,E12.4,' PPM'//
     5' ALFA (CALCULATED)',12X,E12.4,' PERCENT'/)
  108 READ(5,102) NYEAR,IE,IP
      NYE=NYEAR+IE+IP
      READ (5,104) EMO,EMAO,EMAAO
      READ (5,104) Q
      READ (5,104) CRATIO,ARATIO,FINTER
  120 WRITE (6,122) NYEAR,IE,IP,EMAAO
  122 FORMAT (' TOTAL TIME',27X,   I4,' YEARS'//
     1' EXPLORATION UNTIL DISCOVERY',2X,8X,I4,' YEARS'//
     2' CAPITALIZATION TIME',10X,8X,I4,' YEARS'//
     3' MINIMUM ANNUAL EXPLORATION    ',E12.4,' TONS METAL'/)
      FINT#100.*FINTER
      WRITE (6,124) Q,ARATIO,CRATIO,FINT
  124 FORMAT (' PRICE OF CAPITALIZED PRODUCT',1X,E12.4,' €'//
     1' EXPLORATION FRACTION OF PRICE',E12.4//
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     2' RESERVES / ANNUAL CONSUMPTION',E12.4//
     3' INTEREST RATE',16X,E12.4,' PERCENT'/)
C
C-----READ TARGETS IF NOT WORLD RESERVES----------------------------------
C
  150 IF (IND(2).GT.0) GO TO 160
      READ (5,104) (XTAR(I),I=1,NYEAR)
      ALFX=ALOG(FZZ)/ALOG(FXX)
      ALZ=ALOG(ZA)
      DO 154 I=1,NYEAR
  154 RTAR(I)=EXP(ALFX*ALOG(XTAR(I)/XRSM)+ALZ)
      NK=NYEAR+IE+IP
      NZ=NYEAR+1
      DO 158 I=NZ,NK
      XTAR(I)=XTAR(NYEAR)
  158 RTAR(I)=RTAR(NYEAR)
  160 CONTINUE
  178 READ (5,172) (D(I),I=1,NYEAR)
  172 FORMAT (6E12.4)
      DO 173 I=1,50
  173 V(I)=0.
      NY=NYEAR+1
      IJ=NYEAR+IE+IP
      DD=(D(NYEAR)+D(NYEAR-1)+D(NYEAR-2))/3.
      DO 179 I=NY,IJ
  179 D(I)=DD
  200 EM(1)=CRATIO*D(1)
      IF((EMO-D(1)).LT.EM(1)) GO TO 202
      EM(1)=EMO-D(1)
      V(1)=0.
      GO TO 203
  202 V(1)=EM(1)+D(1)-EMO
  203 CONTINUE
      DO 211 IK=2,IJ
      EM(IK)=CRATIO*D(IK)
      IF ((EM(IK-1)-D(IK)).LT.EM(IK)) GO TO 210
      EM(IK)=EM(IK-1)-D(IK)
      V(IK)=0.
      GO TO 211
  210 V(IK)=EM(IK)+D(IK)-EM(IK-1)
  211 CONTINUE
C
      EMA(1)=0.
      DO 204 J=1,IP
  204 EMA(1)=EMA(1)+V(J+1)
      EMAA(1)=EMA(1)-EMAO+V(1)
      IF (EMAA(1).LT.EMAAO) GO TO 205
      IF ((EMAO-V(1)).LT.EMA(1)) GO TO 206
  205 CONTINUE
      EMA(1)=EMAO+EMAAO-V(1)
```

```
      EMAA(1)=EMAAO
  206 CONTINUE
      DO 220 IK=2,IJ
      EMA(IK)=0.
      DO 212 J=1,IP
      JJ=IK+J
  212 EMA(IK)=EMA(IK)+V(JJ)
      EMAA(IK)=EMA(IK)+V(IK)-EMA(IK-1)
      IF (EMAA(IK).LT.EMAAO) GO TO 219
      IF ((EMA(IK-1)-V(IK)).LT.EMA(IK)) GO TO220
  219 CONTINUE
      EMAA(IK)=EMAAO
      EMA(IK)=EMA(IK-1)+EMAA(IK)-V(IK)
  220 CONTINUE
C
C-----WRITE THE STOCK TABLE---------------------------------------------
C
      CUMREQ=RSMALL-(EMO+EMAO)
      ILEV=0
      DO 247 I=1,IJ
  247 HELP(I)=EMAA(I)
  248 CONTINUE
      IF (ILEV.GT.0) GO TO 231
      WRITE (6,230)
      WRITE (6,99) (TIT(I),I=1,18)
  230 FORMAT (1H1/' NON-LEVELED STOCKTABLE'/' ***********************'/)
      GO TO 233
  231 WRITE (6,232)
      WRITE (6,99) (TIT(I),I=1,18)
  232 FORMAT (1H1/' LEVELED STOCKTABLE'/' ******************'/)
  233 CONTINUE
      DO 234 I=1,NYEAR
  234 TOTR(I)=EM(I)+EMA(I)
      WRITE (6,250)
  250 FORMAT (1HO/'  YEAR',5X,'ANNUAL',6X,'CUMULATIVE',4X,'CUMULATIVE',
     14X,'RATIO',
     23X,'CAPITALIZED',3X,'CUM. NOT',6X,'RATIO',5X,'ANNUAL',8X,'TOTAL'/
     39X,'REQUIREMENT',3X,'REQUIREMENT',
     43X,'CAPITALIZED',3X,'CAP.',6X,'ANNUAL',
     56X,'CAPITALIZED',3X,'TOTAL',5X,'DISCOVERY',4X,'RESERVES'/
     637X,'RESERVES',6X,'RES.',18X,'RESERVES',6X,'RES.',6X,'RATE'///)
C
      IF (IND(2).EQ.0) GO TO 251
      WRITE (6,252) CUMREQ,EMO,EMAO
  252 FORMAT (20X,2E14.4,22X,E14.4/)
      GO TO 255
  251 WRITE (6,253) EMO,EMAO
      CUMREQ=0.0
  253 FORMAT (34X,E14.4,22X,E14.4/)
  255 TOT=CUMREQ
```

```
      DO 254 IK=1,NYEAR
      TOT=TOT+D(IK)
      TOTREQ(IK)=TOT
      RR=EM(IK)/D(IK)
      RRA=(EM(IK)+EMA(IK))/D(IK)
      WRITE (6,256) IK,D(IK),TOT,EM(IK),RR,V(IK),EMA(IK),RRA,EMAA(IK)
     1,TOTR(IK)
  254 CONTINUE
  256 FORMAT (I6,3E14.4,F8.1,2E14.4,F8.1,2E14.4/)
C
C-----CALCULATE EXPLORATION DEVELOPMENT FOR WORLD RESERVES--------------
C
      IF (IND(2).EQ.0) GO TO 272
      IF (ILEV.EQ.0) GO TO 269
      IF (IND(3).EQ.0) GO TO 272
  269 CONTINUE
      NYE=NYEAR+IE+IP
      CUMREQ=RSMALL-(EMO+EMAO)
      TD=0.0
      DO 270 I=1,NYE
      TD=TD+D(I)
      RI=EM(I)+EMA(I)+CUMREQ+TD
      CALL TARGET(RI,ZI,XI,I)
      RTAR(I)=ZI
      XTAR(I)=XI
  270 CONTINUE
  272 CONTINUE
C
C-----CALCULATE THE VSMALL-MATRIX---------------------------------------
C
      NYE=NYEAR+IE+IP
      VSMALL(1,1)=V(1)
      SUM=V(1)
      DO 281 I=2,NYE
      VSMALL(I,1)=V(I)
      IF((EMAO-SUM).GE.V(I)) GO TO 280
      VSMALL(I,1)=EMAO-SUM
  280 IF (VSMALL(I,1).LT.(1.E-20)) VSMALL(I,1)=0.
      SUM=SUM+VSMALL(I,1)
  281 CONTINUE
C
      DO 290 J=1,NYE
      JJ=J+1
      SUM=0.
      DO 288 I=1,NYE
      VSMALL(I,JJ)=V(I)
      DO 284 L=1,J
      IF (VSMALL(I,L).LT.(1.E-20)) GO TO 284
      VSMALL(I,JJ)=VSMALL(I,JJ)-VSMALL(I,L)
  284 CONTINUE
```

```
      IF (EMAA(J).GE.(SUM+VSMALL(I,JJ))) GO TO 286
      VSMALL(I,JJ)=EMAA(J)-SUM
  286 IF (VSMALL(I,JJ).LT.(1.E-20)) VSMALL(I,JJ)=0.
      SUM=SUM+VSMALL(I,JJ)
  288 CONTINUE
  290 CONTINUE
C
C-----CALCULATE THE AVERAGES GRADES OF THE CAPITALIZED RESERVES---------
C
      GO=XRSM
      NYEE=NYE-1
      SUM=VSMALL(1,1)/GO
      DO 292 J=1,NYEE
      SUM=SUM+VSMALL(1,J+1)/XTAR(J)
  292 CONTINUE
      G(1)=((EMO-D(1))/GO+SUM)*1.E+6
      G(1)=EM(1)*1.E+6/G(1)
C
      DO 296 I=2,NYEAR
      SUM=VSMALL(I,1)/GO
      DO 294 J=1,NYEE
      SUM=SUM+VSMALL(I,J+1)/XTAR(J)
  294 CONTINUE
      G(I)=((EM(I-1)-D(I))/G(I-1)+SUM)*1.E+6
      G(I)=EM(I)*1.E+6/G(I)
  296 CONTINUE
C
C-----CALCULATE THE UNIT COST DEPENDING ON GRADE/SIZE OF TARGET---------
C
      DO 558 IA=1,NYE
      ZZZ=RTAR(IA)
      GRA=XTAR(IA)
      DDP=(ZZZ/GRA)*1.E+6
      VD=(DDP/RHO)*1.E-9
      AD=(VD/(BDA**2*CDB))**0.3333333
      DD=AD*(1.+BDA+BDA*CDB)
      GAMD=XENV/EXP(0.015*ALFA*ALOG(24400./DD))
      SIGD=SQRT(2.*ALOG(XENV/GAMD))
      ENP=ALOG(GRA/GAMD)/SIGD
      IPP=2
      CALL PNP(P,ENP,IPP)
      ENDEP=P*1.E+18/DDP
      U(IA)=XRSM*DSMALL*RSMALL*ARATIO*Q*1.E-6/(DD*ENDEP*ZA)
      T(IA)=U(IA)*1.E+6/GRA
  558 CONTINUE
C
C-----CALCULATE THE NETT INVESTMENTS EQUAL PARTS B(I)-------------------
C
      SUM=0.
      DO 320 L=1,IE
```

```
  320 SUM=SUM+(1.+FINTER)**L
      FACA=1./SUM
      DO 321 I=1,50
  321 B(I)=0.0
      DO 326 J=1,NYE
      SUM=0.
      DO 324 I=1,NYE
  324 SUM=SUM+VSMALL(I,J+1)*T(I)/((1.+FINTER)**(I-J))
  326 B(J)=FACA*SUM
C
C-----CALCULATE ZERO TIME INVESTMENT -----------------------------------
C
      SUM=0.
      DO 330 I=1,NYE
  330 SUM=SUM+VSMALL(I,1)*T(I)/(1.+FINTER)**I
      FACA=SUM
      IEM=IE-1
      SUM=0.
      DO 334 IN=1,IEM
      IEN=IE-IN
      SUMA=0.
      DO 332 L=1,IEN
  332 SUMA=SUMA+(1.+FINTER)**L
  334 SUM=SUM+B(IN)*SUMA
      RINVO=FACA+SUM
C
C-----CALCULATE THE INVESTMENTS ----------------------------------------
C
      DO 352 I=1,NYE
      C(I)=0.
      DO 349 J=1,NYE
  349 C(I)=C(I)+VSMALL(I,J)*T(J)
      IN=I+IE-1
      DINV(I)=0.
      DO 350 J=I,IN
  350 DINV(I)=DINV(I)+B(J)
  352 CONTINUE
C
C-----CALCULATE THE UNIT COST CAPITALIZED RESERVES---------------------
C
      DO 357 I=1,NYEAR
      IF(G(I).LT.XTAR(1)) GO TO 353
      TG(I)=T(1)
      GO TO 357
C
  353 DO 354 J=1,NYEAR
      IF(G(I).GE.XTAR(J)) GO TO 356
  354 CONTINUE
      WRITE (6,355)
  355 FORMAT (///' ERROR EXIT 4'//)
```

```
      STOP
  356 TG(I)=T(J-1)+(XTAR(J-1)-G(I))*(T(J)-T(J-1))/(XTAR(J)-XTAR(J-1))
  357 CONTINUE
C
      ACDINV(1)=(RINVO+DINV(1))*(1.+FINTER)-C(1)
      DINGR(1)=DINV(1)-D(1)*TG(1)
      DO 360 I=2,NYE
      ACDINV(I)=(ACDINV(I-1)+DINV(I))*(1.+FINTER)-C(I)
  360 DINGR(I)=DINV(I)-D(I-1)*TG(I)
C
C-----WRITE THE INVESTMENT TABLE----------------------------------------
C
      WRITE (6,362)
      WRITE (6,99) (TIT(I),I=1,18)
  362 FORMAT (1H1/' TABLE OF INVESTMENTS'/' *********************'///)
      WRITE (6,364)
  364 FORMAT (' YEAR  TARGET DEPOSIT    PROB. UNIT COSTS    DISC.  TOT.N
     1ET   RETURN      NEW     CUM.  AV.GRADE')
      WRITE (6,366)
  366 FORMAT (10X,'TONS    GRADE  £/TON     £/TON',7X,'RATE INVESTM.  BY
     1CAP. INVESTM. INVESTM. CAP.RES.')
      WRITE (6,367)
  367 FORMAT (9X,'METAL     PPM   OF ORE  OF METAL   TONS',7X,'M£',7X,'M
     1£',7X,'M£',7X,'M£',7X,'M£'//)
      EMI=1.E-6
      RINV=RINVO*EMI
      WRITE (6,368) RINV
  368 FORMAT (79X,F7.1/)
C
      DO 370 I=1,NYEAR
      RES(1)=RTAR(I)
      RES(2)=XTAR(I)
      RES(3)=U(I)
      RES(4)=T(I)
      RES(5)=EMAA(I)
      RES(6)=DINV(I)*EMI
      RES(7)=C(I)*EMI
      RES(8)=DINGR(I)*EMI
      RES(9)=ACDINV(I)*EMI
      RES(10)=G(I)
      WRITE (6,369) I,(RES(J),J=1,10)
  370 CONTINUE
  369 FORMAT (I5,2F9.0,F9.2,2F9.0,4F9.1,F9.0/)
C
C-----DRAW THE CURVES --------------------------------------------------
C
      IF (IND(5).EQ.0) GO TO 401
      CALL FINIM (0.,0.)
      START=0.
      SLET =0.2
```

```
      SIZX=10.
      SIZY=5.0
      SIZYY=SIZY+1.0
      TEXT=START+SIZY*0.5
      TEX=5.0
      X(1)=0.
      NN=NYEAR+1-IE-IP
      DO 379 I=2,NN
  379 X(I)=FLOAT(I-1)
      DO 399 IGR=1,NGRAPH
      NGR=IGRAPH(IGR)
      GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16),NGR
    1 CONTINUE
      Y(1)=0.
      DO 381 I=2,NN
  381 Y(I)=D(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,19HANNUAL REQUIREMENTS,19)
      CALL FINIM(TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,5H YEAR,-5,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
    2 CONTINUE
      DO 382 I=2,NN
  382 Y(I)=EMAA(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,21HANNUAL DISCOVERY RATE,21)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
    3 CONTINUE
      Y(1)=EMAO
      DO 383 I=2,NN
  383 Y(I)=EMA(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,24HNON CAPITALIZED RESERVES,24)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
    4 CONTINUE
      Y(1)=EMO
      DO 384 I=2,NN
  384 Y(I)=EM(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,20HCAPITALIZED RESERVES,20)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
    5 CONTINUE
      Y(1)=0.
      DO 385 I=2,NN
```

```
  385 Y(I)=V(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,21HANNUAL CAPITALIZATION,21)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
    6 CONTINUE
      Y(1)=0.
      DO 386 I=2,NN
  386 Y(I)=DINV(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,21HANNUAL NET INVESTMENT,21)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
    7 CONTINUE
      Y(1)=0.
      DO 387 I=2,NN
  387 Y(I)=C(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,13HANNUAL INCOME,13)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
    8 CONTINUE
      Y(1)=RINVO
      DO 388 I=2,NN
  388 Y(I)=ACDINV(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,21HCUMULATIVE INVESTMENT,21)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
    9 CONTINUE
      Y(1)=0.
      DO 389 I=2,NN
  389 Y(I)=DINGR(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,14HNEW INVESTMENT,14)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
   10 CONTINUE
      IF (IND(1).EQ.0) GO TO 391
      Y(1)=0.
      DO 390 I=2,NN
  390 Y(I)=W(I-1,1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,26HEXPLORATION AREA(AV. DEP.),26)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
```

```
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
  391 CALL FINIM (0.0,SIZYY)
      GO TO 399
   11 CONTINUE
      IF (IND(1).EQ.0) GO TO 391
      Y(1)=0.
      DO 392 I=2,NN
  392 Y(I)=W(I-1,2)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,28HEXPL. PRICE PER KM2(AV.DEP.),28)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
   12 CONTINUE
      IF (IND(3).EQ.0) GO TO 391
      Y(1)=0.
      DO 393 I=2,NN
  393 Y(I)=W(I-1,3)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,27HEXPLORATION AREA(SPEC.DEP.),27)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
   13 CONTINUE
      IF (IND(3).EQ.0) GO TO 391
      Y(1)=0.
      DO 394 I=2,NN
  394 Y(I)=W(I-1,4)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,28HEXPL. PRICE PER KM2(SP.DEP.),28)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
   14 CONTINUE
      Y(1)=0.
      DO 395 I=2,NN
  395 Y(I)=TOTREQ(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,23HCUMULATIVE REQUIREMENTS,23)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
   15 CONTINUE
      Y(1)=EMO+EMAO
      DO 396 I=2,NN
  396 Y(I)=TOTR(I-1)
      CALL SYMBL4 (0.0,TEXT,SLET,0.0,14HTOTAL RESERVES,14)
      CALL FINIM (TEX,0.0)
      CALL DESSIN (X,Y,NN,1,1,1,0,0,SIZX,SIZY,0,0,1H ,-1,1H ,1,0)
```

```
      CALL FINIM (-TEX,SIZYY)
      GO TO 399
   16 CONTINUE
      GO TO 391
  399 CONTINUE
      AS=SIZYY*FLOAT(NGRAPH)
      AT=TEX+SIZX+5.
      CALL FINIM (AT,-AS)
  401 CONTINUE
C
C-----PERFORM THE LEVELING -------------------------------------------
C
      IF(IND(4).EQ.0) GO TO 461
      IF(ILEV.GT.0) GO TO 408
      READ (5,402) NLEV
      IF(NLEV.EQ.0) GO TO 405
      READ (5,404) (ALE(I),I=1,NLEV)
  402 FORMAT (12I6)
  404 FORMAT (6E12.4)
  405 ILEV=ILEV+1
C
C-----FIRST INTERVAL--------------------------------------------------
C
      IEE=IE-1
      SUMM=0.
      SUMMJ=0.
      SUMMJ2=0.
      DO 410 J=1,IEE
  410 SUMM=SUMM+EMAA(J)
      SUMMA=SUMM/FLOAT(IEE)
      DO 411 J=1,IEE
      SUMMJ=SUMMJ+FLOAT(2*J-IE)*(EMAA(J)-SUMMA)
  411 SUMMJ2=SUMMJ2+FLOAT(2*J-IE)**2
      AL=2.*SUMMJ/SUMMJ2
C
      AL=SUMMJ/SUMMJ2
      BL=SUMM/FLOAT(IEE)-0.5*AL*FLOAT(IE)
      DO 412 J=1,IEE
  412 SUMM=SUMM-(FLOAT(J)*AL+BL)
      BL=BL+SUMM/FLOAT(IEE)
      DO 416 I=1,IEE
  416 EMAAN(I)=AL*FLOAT(I)+BL
      GO TO 409
  408 IF (ILEV.GT.NLEV) GO TO 462
      DO 413 I=1,NYE
  413 EMAA(I)=HELP(I)
      AL=ALE(ILEV)
      ILEV=ILEV+1
  409 CONTINUE
C
```

```
C-----FORWARD LEVELING-----------------------------------------------
C
      ART=ATAN(AL)
      IST=IEE
      EMST=EMAA(IEE)
  420 JIST=IST+1
      IF(JIST.GT.(NYE-1)) GO TO 434
      IA1=JIST
      A1=EMAA(JIST)-EMST
      ARTA=ATAN(A1)
      JJ=IST+2
      DO 426 J=JJ,NYE
      SUMM=0.
      SUML=0.
      DO 424 L=JIST,J
      SUMM=SUMM+EMAA(L)
  424 SUML=SUML+FLOAT(L)
      A2=(SUMM-EMST*FLOAT(J-IST))/(SUML-FLOAT(IST*(J-IST)))
      IF (A2.LT.A1) GO TO 426
      ARTB=ATAN(A2)
      IF (ABS(ARTB-ART).GT.ABS(ARTA-ART)) GO TO 426
      A1=A2
      ARTA=ARTB
      IA1=J
  426 CONTINUE
      AL=A1
      BL=EMST-A1*IST
      DO 430 J=JIST,IA1
  430 EMAAN(J)=AL*FLOAT(J)+BL
      ART=ARTA
      IST=IA1
      EMST=EMAAN(IST)
      GO TO 420
  434 IF(IST.EQ.NYE) GO TO 440
      EMAAN(NYE)=EMAA(NYE)
      EMAAN(NYEAR)=EMAA(NYEAR)
  440 CONTINUE
C
      EMAA(1)=EMAAN(1)
      EMA(1)=EMA0-V(1)+EMAA(1)
      DO 460 I=2,NYE
      EMAA(I)=EMAAN(I)
  460 EMA(I)=EMA(I-1)-V(I)+EMAA(I)
      GO TO 248
  462 IF (IND(5).EQ.0) GO TO 461
      CALL FINTRA
  461 CONTINUE
      STOP
      END
```

```
      SUBROUTINE TARGET(RI,ZI,XI,IYEAR)
C
C     TARGET CALCULATES FOR A REQUESTED TOTAL WORLD METAL
C     RESERVE THE AVERAGE GRADE AND SIZE OF THE TARGET DEPOSITS
C
      COMMON XRSM,ZA,RSMALL,ALFA,DSMALL,FX,FZ,XENV,CUMREQ
      ALFG=ALOG(FX)
      R=1.E+18
      DLARGE=24400.
      IF(RI.GT.RSMALL) GO TO 105
      ZI=ZA
      XI=XRSM
      RETURN
C
  105 XI=XRSM
      IWAY=1
C
  110 ZI=EXP(ALOG(FZ)*ALOG(XI/XRSM)/ALFG+ALOG(ZA))
      DI=DSMALL*((XRSM*ZI)/(XI*ZA))**0.333333
      GAMM=XENV/EXP(0.015*ALFA*ALOG(DLARGE/DI))
      SIGD=SQRT(2.*ALOG(XENV/GAMM))
      ENP=ALOG(XI/GAMM)/SIGD
      IPP=2
      CALL PNP(P,ENP,IPP)
      RIA=P*R*XI*1.E-6
      GO TO (115,120),IWAY
C
  115 CONTINUE
      XIB=XI
      RIB=RIA
      ZIB=ZI
      DEL=1.0
      DO 135 KK=1,6
      DEL=DEL*0.1
      DO 125 J=1,9
      XI=XIB-FLOAT(J)*DEL*XRSM
      IWAY=2
      GO TO 110
C
  120 IF (RIA.GT.RI) GO TO 130
      XIB=XI
      RIB=RIA
      ZIB=ZI
  125 CONTINUE
  130 CONTINUE
  135 CONTINUE
      XI=XIB
      ZI=ZIB
      RETURN
      END
```

```
      SUBROUTINE PNP%P,ENP,JA¤
      DIMENSION XLPG%60¤,YNP%60¤
      DATA
     1XLPG% 1¤,XLPG% 2¤,XLPG% 3¤,XLPG% 4¤,XLPG% 5¤,XLPG% 6¤,XLPG% 7¤,
     2XLPG% 8¤,XLPG% 9¤,XLPG%10¤,XLPG%11¤,XLPG%12¤,XLPG%13¤,XLPG%14¤,
     3XLPG%15¤,XLPG%16¤,XLPG%17¤,XLPG%18¤,XLPG%19¤,XLPG%20¤,XLPG%21¤,
     4XLPG%22¤,XLPG%23¤,XLPG%24¤,XLPG%25¤,XLPG%26¤,XLPG%27¤,XLPG%28¤,
     5XLPG%29¤,XLPG%30¤,XLPG%31¤,XLPG%32¤,XLPG%33¤,XLPG%34¤,XLPG%35¤,
     6XLPG%36¤,XLPG%37¤,XLPG%38¤,XLPG%39¤,XLPG%40¤,XLPG%41¤,XLPG%42¤,
     7XLPG%43¤,XLPG%44¤,XLPG%45¤,XLPG%46¤,XLPG%47¤,XLPG%48¤,XLPG%49¤,
     8XLPG%50¤,XLPG%51¤,XLPG%52¤,XLPG%53¤,XLPG%54¤,XLPG%55¤,XLPG%56¤/
     10.301030,0.337080,0.375986,0.417836,0.462712,0.510692,0.561848,
     20.616250,0.673960,0.735040,0.799545,0.867528,0.939039,1.014122,
     31.092821,1.175176,1.261225,1.351001,1.444539,1.541868,1.643017,
     41.748012,1.856878,1.969639,2.086316,2.206930,2.331499,2.460042,
     52.592575,2.729114,2.869674,3.014269,3.162912,3.315615,3.472388,
     63.633245,3.798199,3.967251,4.140412,4.317712,4.499115,4.684625,
     74.874351,5.068057,5.265977,5.468369,5.674492,5.884772,6.098426,
     86.318250,6.536745,6.766082,6.997476,7.224720,7.474597,7.650689/
      DATA
     1YNP% 1¤,YNP% 2¤,YNP% 3¤,YNP% 4¤,YNP% 5¤,YNP% 6¤,YNP% 7¤,YNP% 8¤,
     2YNP% 9¤,YNP%10¤,YNP%11¤,YNP%12¤,YNP%13¤,YNP%14¤,YNP%15¤,YNP%16¤,
     3YNP%17¤,YNP%18¤,YNP%19¤,YNP%20¤,YNP%21¤,YNP%22¤,YNP%23¤,YNP%24¤,
     4YNP%25¤,YNP%26¤,YNP%27¤,YNP%28¤,YNP%29¤,YNP%30¤,YNP%31¤,YNP%32¤,
     5YNP%33¤,YNP%34¤,YNP%35¤,YNP%36¤,YNP%37¤,YNP%38¤,YNP%39¤,YNP%40¤,
     6YNP%41¤,YNP%42¤,YNP%43¤,YNP%44¤,YNP%45¤,YNP%46¤,YNP%47¤,YNP%48¤,
     7YNP%49¤,YNP%50¤,YNP%51¤,YNP%52¤,YNP%53¤,YNP%54¤,YNP%55¤,YNP%56¤/
     10.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0,1.1,1.2,1.3,1.4,1.5,
     21.6,1.7,1.8,1.9,2.0,2.1,2.2,2.3,2.4,2.5,2.6,2.7,2.8,2.9,3.0,3.1,
     33.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9,4.0,4.1,4.2,4.3,4.4,4.5,4.6,4.7,
     44.8,4.9,5.0,5.1,5.2,5.3,5.4,5.5/
      IF%JA-1¤102,102,200
C
C-----THE CALCULATION OF NP AS FUNCTION OF P----------------------------
C
  102 PP#-ALOG10%P¤
      IF%PP-15.0¤108,108,104
  104 JA#3
  105 WRITE %6,106¤ P
  106 FORMAT %29H ERROR ARGUMENT TOO SMALL  P#,E12.5¤
      RETURN
  107 FORMAT %29H ERROR ARGUMENT TOO LARGE  P#,E12.5¤
  108 IF%PP-7.650689¤120,110,110
  110 ENP#2.27316&0.465285*PP-0.005688*PP**2
      IF%ENP-7.5¤114,114,112
  112 JA#2
      RETURN
  114 IF%ENP-7.0¤118,118,116
  116 JA#1
      RETURN
```

```
  118 JA#0
      RETURN
  120 IF%PP.GT.XLPG%1□□ GO TO 121
      JA#4
      WRITE %6,107□ P
      RETURN
  121 DO 122 I#1,56
      IF%PP-XLPG%I□□124,124,122
  122 CONTINUE
      GO TO 104
  124 IN#I-1
      ENP#%%PP-XLPG%IN□□/%XLPG%IN&1□-XLPG%IN□□□*%YNP%IN&1□-YNP%IN□□&YNP%
     1IN□
      JA#0
      RETURN
C
C-----THE CALCULATION OF P AS A FUNCTION OF NP-------------------------
C
  200 IF%ENP-5.5□202,202,208
  202 JA#0
      DO 204 I#1,56
      IF%ENP-YNP%I□□206,206,204
  204 CONTINUE
      GO TO 208
  206 IN#I-1
      PP#%%ENP-YNP%IN□□/%YNP%IN&1□-YNP%IN□□□*%XLPG%IN&1□-XLPG%IN□□&XLPG%
     1IN□
      P#10.**%-PP□
      RETURN
  208 IF%ENP-7.9□214,214,210
  210 WRITE %6,212□ ENP
  212 FORMAT %30H ERROR ARGUMENT TOO LARGE  NP#,E12.5□
      JA#3
      RETURN
  214 ROOT#2072.51-175.79*ENP
  216 PP#40.9006-SQRT%ROOT□
      P#10.**%-PP□
      JA#0
      IF%ENP-7.0□218,218,220
  218 RETURN
  220 IF%ENP-7.5□222,222,224
  222 JA#1
      RETURN
  224 JA#2
      RETURN
      END
```

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Alfred Nobel

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