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A ready reckoner for early evaluation of open-pit base and precious metal projects.

by

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Introduction

Investment in mineral exploration will yield a return only if the exploration effort is sustained on those prospects which are capable of being developed into viable mines. The location of a prospect, and its topography and geology can at a very early stage give broad indications of its viability; the effects of these parameters should be continually reassessed, to ensure that the exploration effort remains effectively directed.

This ready reckoner is based on FIRST THREE YEARS PROFIT = TOTAL CAPITAL COST, and is designed to give a quick indication of a prospect's potential viability.

The assessment is based on various functions that are plotted as graphs and take into account basic capital and operating costs for different mineral orebodies and different yearly rates of tonnage treated.

The Basic Capital Cost outlined in the graphs includes

(1) Pit equipment
(2) Concentrater
(3) Support facilities
(4) Power
(5) Basic water supply
(6) Feasibility study
(7) Working capital

The Basic Operating Cost outlined in the graphs includes

(1) Labour
(2) Spares
 (a) maintenance
 (b) expendables

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(3) Power (fuels, etc).

(4) Administration

Mineral associations

A separate production function has been calculated for each of the several mineral associations considered, because basic capital and operating costs are not the same for each of the different types of orebody (Figs. 1-6).

The types of orebody considered are gold-silver (Fig. 1), copper (Fig. 2), copper-gold-silver (Fig. 3), lead-zinc-silver (Fig. 4), copper-silver-lead-zinc (Fig. 5), and tin (Fig. 6).

There is a separate graph (Fig. 7) for the basic township capital cost for the various hypothetical mines, at different yearly treatment rates.

Variable capital cost items

Before the final calculation is made the TOTAL CAPITAL COST is required. To obtain this, it is necessary to add to the given basic capital cost (from the graphs) the capital cost of the following 11 variables which are unique to each prospect

(1) Tonnage

(2) Mine life

(3) Net value of the ore

(4) Overburden ratio

(5) Additional cost of water supply

(6) Infrastructure

(7) Additional cost of township

(8) Distance from capital city

(9) Distance from smelter

(10) Smelting and realisation cost

(11) Operating cost

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Variable operating cost

Also required for the final calculation is the TOTAL OPERATING COST. This is obtained by adding the overburden charge to the basic operating cost. (In this exercise the overburden is removed by contractors at a charge of $1.5/tonne; the company supplies the housing, the contractor supplies the equipment). An average cost of tailings disposal and environmental control is given as $0.50/tonne. Difficult local situations may necessitate an increase (personally estimated) in this figure.

Calculation explanatory notes Previous mine assessments indicate that, if three years' production profit is equal to or greater than the Total Initial Capital Cost, the prospect is viable. The formula thus is:

(3xyearly tonnage x (net value of ore/tonne-operating cost/tonne) -capital cost = 0

If the above expression is positive the prospect is viable.

To apply this formula, one must necessarily incorporate the 11 variables listed above:

(1) Tonnage

Assess the tonnage potential of the prospect and increase tonnage by 5 percent to allow for dilution.

(2) Mine life

15 years appears to be the best average.

(3) Net value of the ore

Estimate the grade of all economic minerals in the deposit. Convert this grade to a net value at 80% recovery (to allow a 90% mill recovery, 5% pit dilution , 5% smelter loss); then deduct smelting, transport, and royalty charges.

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(4) Overburden ratio

Calculate the overburden ratio. This ratio affects both capital and operating costs.

The overburden ratio should not be taken above 12:1; from this point on it is an underground operation.

(5) Water supply

Average water supply requirements are included in the basic capital cost. If the water supply is more than 5 km from the minesite add $1.00/tonne of yearly production to the capital cost for every additional 10 km or part thereof.

(6) Infrastructure

This can be a major capital cost factor. An assessment of the needs and cost of the infrastructure must be made and added to the capital cost. Consideration should be given to the following:

(1) Pre-mining pit development
(2) Roads
(3) Railway and rolling stock
(4) Bridges
(5) Port
(6) Site preparation

(7) Township

A township may or may not be required and is considered separately from infrastructure. Basic township cost is taken from Figure 7 and increased to accommodate personnel for overburden removal. The total township cost is calculated as follows:

$$\text{Total township cost} = \text{basic township cost} \times \left(1 + \frac{\text{overburden ratio}}{8}\right)$$

(8) Distance from capital city

This factor can add appreciably to the capital cost and is calculated as: yearly tonnage multiplied by a factor of 7.0, multiplied by 10 cents/tonne/km, divided by days/year.

$$= \frac{\text{yearly tonnage} \times 7.0 \times 0.1 \times \text{distance}}{330} = \$$$

(9) Distance from smelter

Similarly, distance can add to the cost of concentrate transport and subsequent metal realisation.

(10) Smelting and realisation costs

For the purposes of this ready reckoner, gold and silver can be neglected. The copper-smelting charge is taken as $375.0/tonne of copper the lead-smelting charge as $140/tonne of lead, and the zinc-smelting charge as $280.0/tonne. Tin smelting charge, initially is $100.0/tonne of concentrate, however impurities such as copper, iron arsenic and others draw severe penalties. It is essential prior to calculation to obtain samples and forward them to a Tin smelter for early analysis of such penalties.

(11) Operating cost

The basic operating cost is taken from the appropriate graph at the accepted yearly tonnage rate. Operating cost is affected by overburden removal, and addition should be made as follows.

Total operating cost ($) = basic operating cost from graph + (overburden factor x $1.2).

CALCULATION FOR A HYPOTHETICAL LEAD-ZINC-SILVER MINE

TYPE OF METAL DEPOSIT ....Lead-zinc-silver....... Figure No. ....4.......

POSSIBLE TONNAGE ....30 000 000 + 5% Dilution........................

POSSIBLE GRADE OF ORE: Gold ....Nil.......... Silver ...200 g/t..........

Copper ..Nil.....% Lead ..5.0.......% Zinc ..4.0..%

Tin .....Nil.....%

LIFE OF MINE ...15 years........

YEARLY PRODUCTION ..2.1×10^6 tonnes.. = $\frac{\text{Possible Tonnes}}{\text{Life of Mine}}$ $\frac{31\ 500\ 000}{15}$

OVERBURDEN RATIO ....4:1 = 120 000 000 Tonnes........................

DISTANCE FROM SMELTER ....400......... km

DISTANCE FROM CAPITAL CITY ....1000........ km

METAL PRICES

GOLD	$	..N.A..../kg
SILVER	$	..150..../kg
COPPER	$	..N.A..../tonne
LEAD	$	..700..../tonne
ZINC	$	..632..../tonne
TIN	$	..N.A..../tonne

NET VALUE/TONNE OF METAL

The at-mine value/tonne of metal is dependent on the cost of transport and smelting charges. The method of assessment is as follows:

$$\text{Net value} = \text{Metal Price} - \left(\left(\frac{100}{\%\ \text{metal in concentrate}} \times \text{distance to smelter} \times \text{carting charge/tonne of concentrates}\right) + \text{smelter charges}\right).$$

			$
GOLD	kg		N.A.
SILVER	kg		150.0
COPPER	$/tonne ...	- ((4.0 x N.A. x 0.05) + 375) =	-
LEAD	$/tonne 700	- ((1.7 x ...... x 0.05) + 140) =	526
ZINC	$/tonne 632	- ((1.8 x ...... x 0.05) + 280) =	316
TIN	$/tonne N.A.	- .... - .... =	....

NET VALUE/TONNE OF ORE

The at-mine value/tonne of ore is a function of the ((at-mine value of the metal x grade x recovery) - royalty) (royalty, taken here as 2.5%)

$

Net metal price/kg x grade (g/t) x recovery/1000.0

GOLD (N.A. x N.A. / 1.000.0 x 0.80) = -

Net metal price/kg x grade (g/t) x recovery/1000.0

SILVER (150 x 200 / 1.000.0 x 0.80) = 24.0

Net value of metal/tonne x grade (%) x recovery x royalty/1000

COPPER (- x - / 1000.0 x 0.80 x 0.975) = -

Net value of metal/tonne x grade (%) x recovery x royalty/1000

LEAD (526 x 5.0 / 100.0 x 0.80 x 0.975) = 20.51

Net value of metal/tonne x grade (%) x recovery x royalty/1000

ZINC (316 x 4.0 / 100.0 x 0.80 x 0.975) = 9.86

Net value of metal/tonne x grade (%) x recovery x royalty/1000

TIN (N.A. x N.A. / 100.0 x 0.65 x 0.975) = -

Note average recovery for tin is 65%

TOTAL NET VALUE/TONNE OF ORE AT MINE = 54.37

CAPITAL COST

$ x 10^6

BASIC CAPITAL COST (Fig. ..4....) ....122.0...

EXTRA COST OF WATER add $1.0 x yearly tonnage for each 10 km or part thereof in excess of 5 km)

....6.0.. km = ..$1.0........... x ..2.1........ ....2.1..

COST OF DISTANCE FROM CAPITAL CITY

(Distance (km) x yearly tonnage x 7.0 x 0.1)/330

....1000.. x 2.1 x 10^c/330.0 .... x .....7.0..... ....4.5..

COST OF TOWNSHIP

Basic cost (from Fig. ..7..) x (1 + overburden factor/8.0)

.......20............... x (1 + ...4......../8.0) ....30.0..

COST OF INFRASTRUCTURE (make personal assessments)

	$\$10^6$
ROADS	..3.0....
PIT DEVELOPMENT	..0.5....
BRIDGE	....
SITE PREPARATION	..0.5....
PORT	....
RAILWAY - ROLLING STOCK	....
TOTAL	..4.0....

......4.0..

TOTAL CAPITAL COST 162.6

OPERATING COST

		$/tonne
BASIC OPERATING COST/TONNE (Fig. 4)		13.1
COST OF OVERBURDEN REMOVAL		
Overburden factor	x $1.5	
4.0	x $1.5	6.0
COST OF TAILINGS DISPOSAL AND ENVIRONMENTAL CONTROL	$0.50	0.50
(Difficult locations may increase the figure and an on-site estimate may be needed).		....
TOTAL OPERATING COST		19.6

VIABILITY CALCULATION

$\$10^6$

FORMULA

(3 x yearly tonnage (net value/tonne of ore - operating cost)) - capital cost = 0/0

$(3 \times 2.1 \times 10^6\ (54.37 - 19.60)) - 162.6 = + 56.45$

If result positive, prospect viable

IS PROSPECT VIABLE YES

Fig. 1

GOLD-SILVER OREBODY

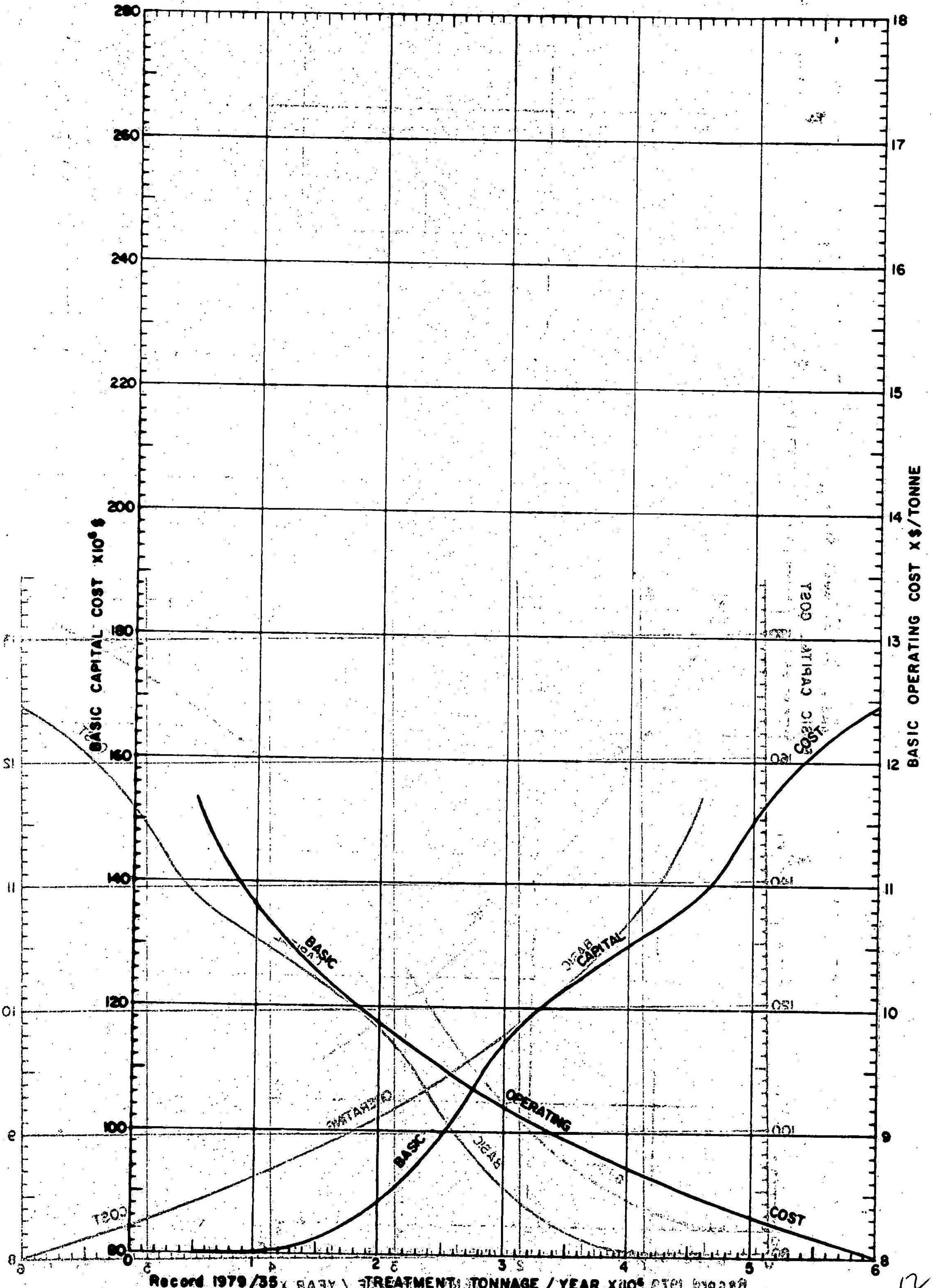

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Fig. 2

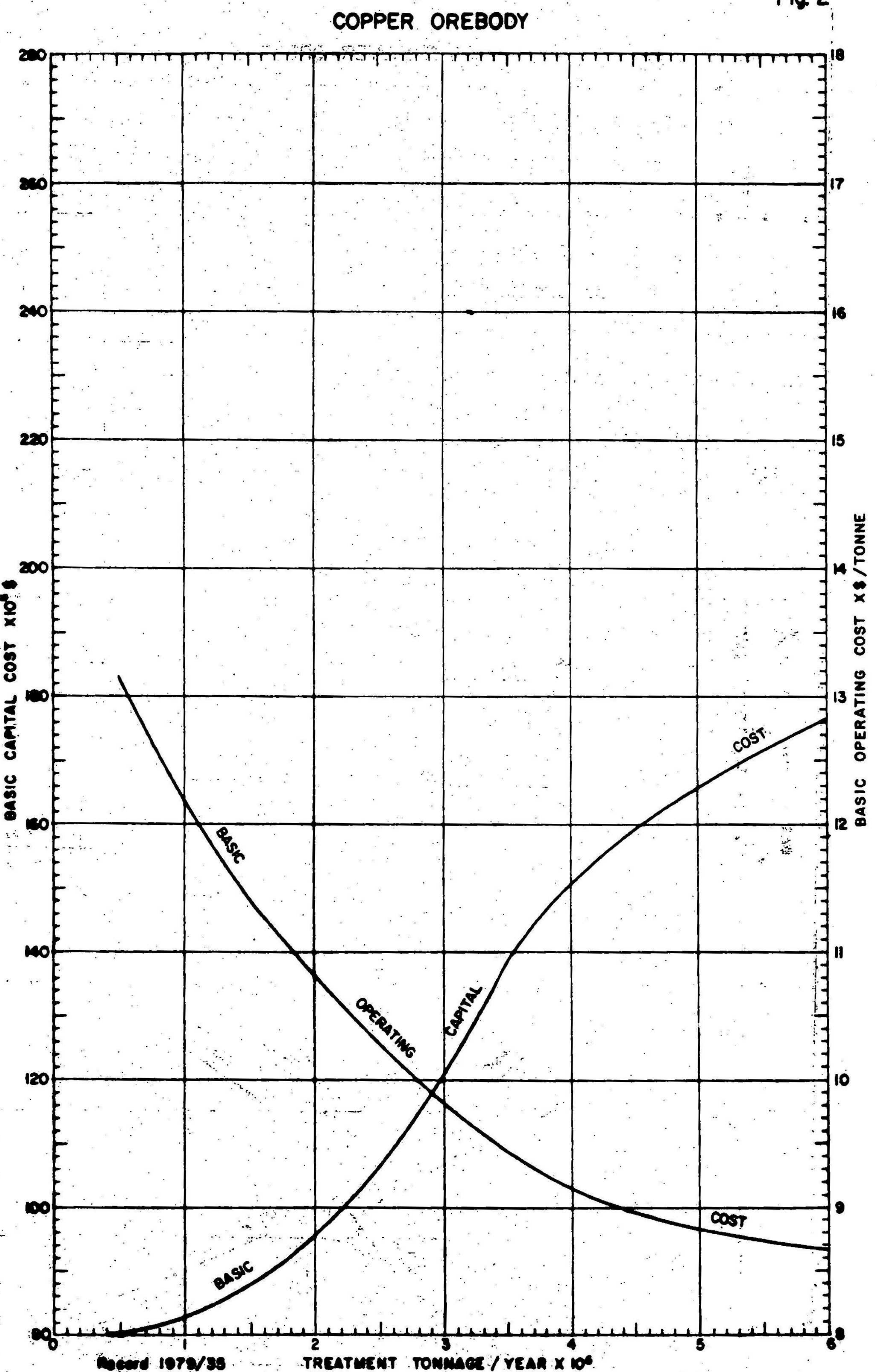

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Fig. 3

COPPER-GOLD-SILVER OREBODY

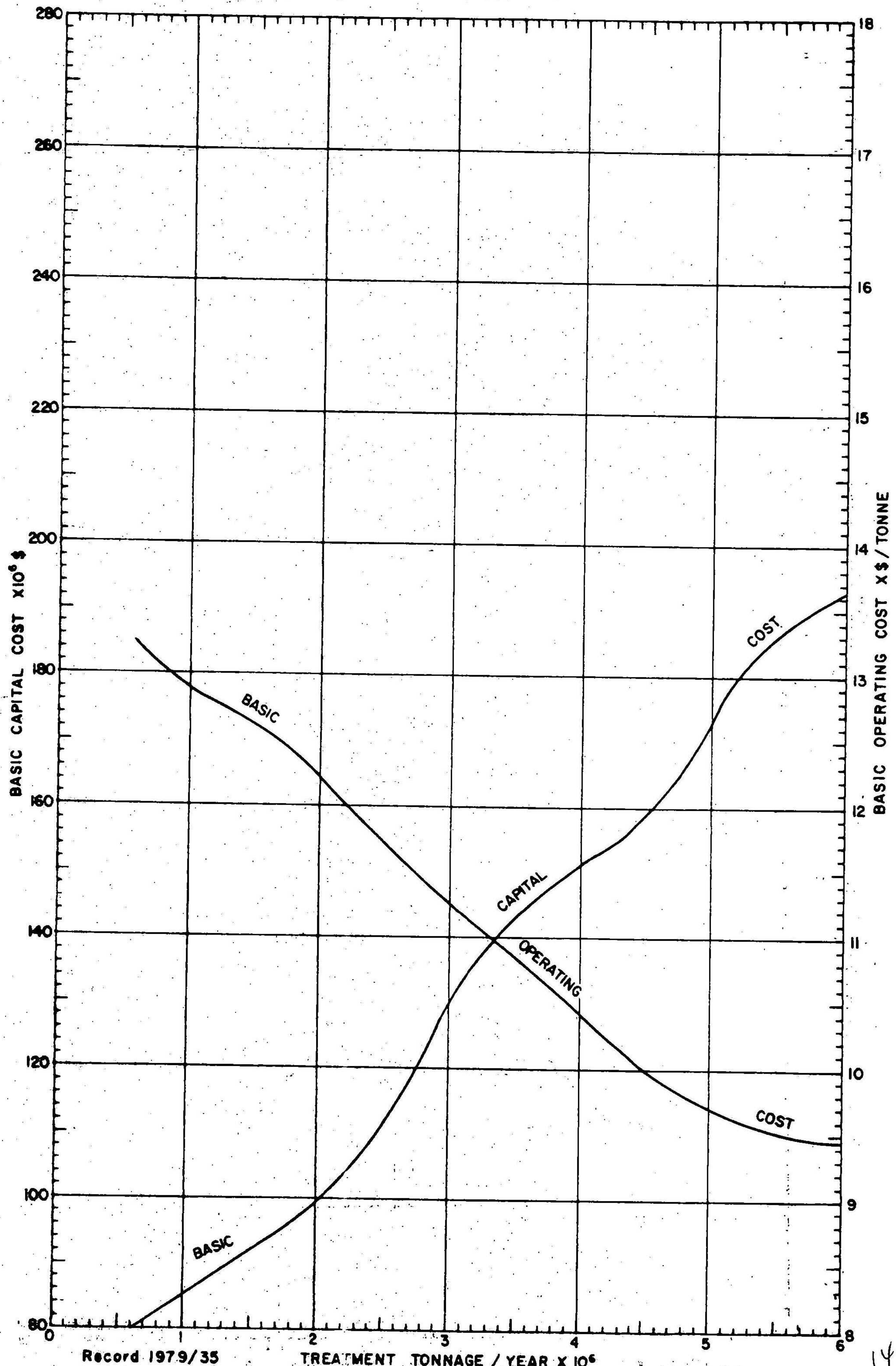

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Fig. 4.

SILVER - LEAD - ZINC OREBODY

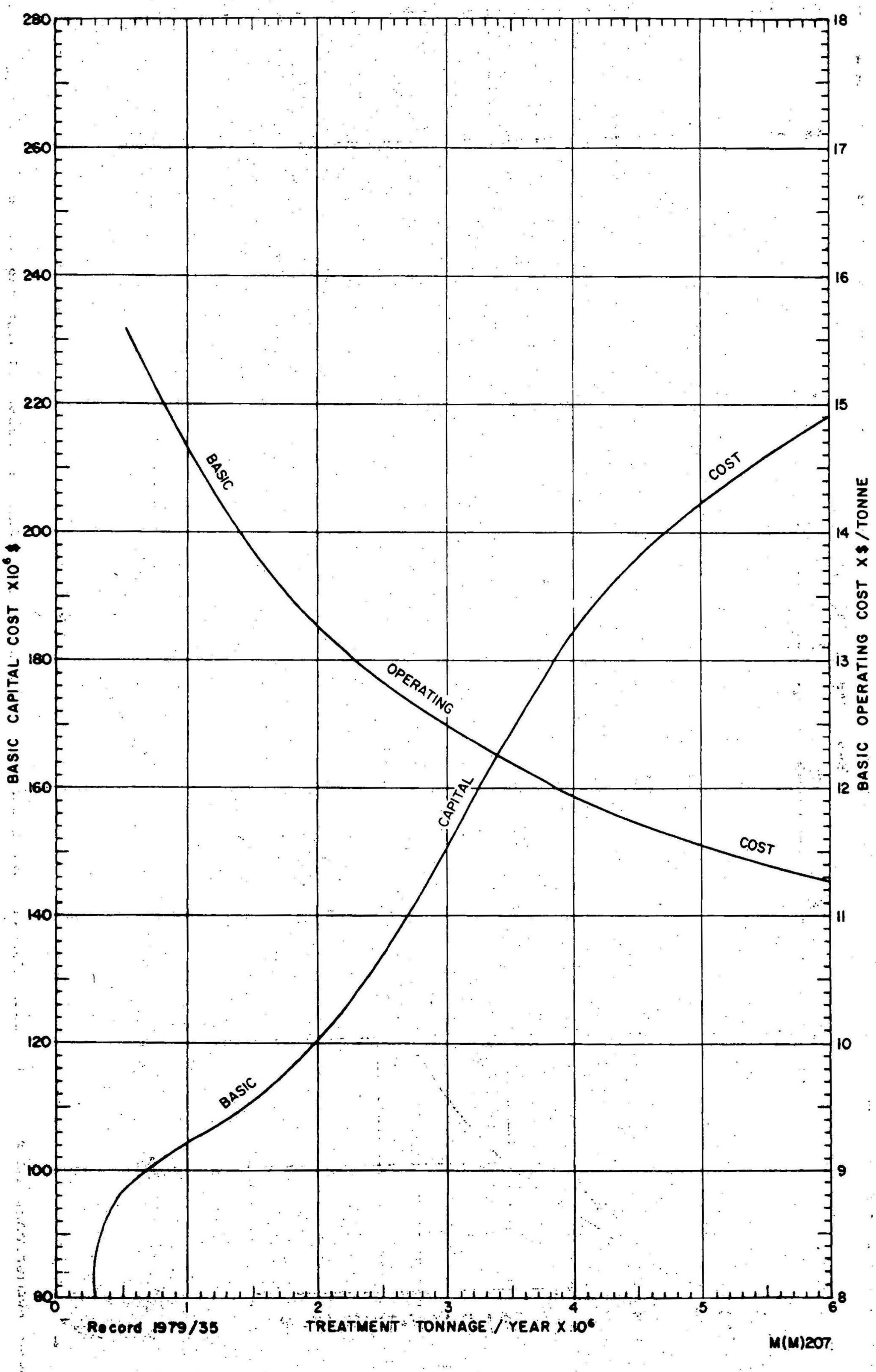

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Fig.5

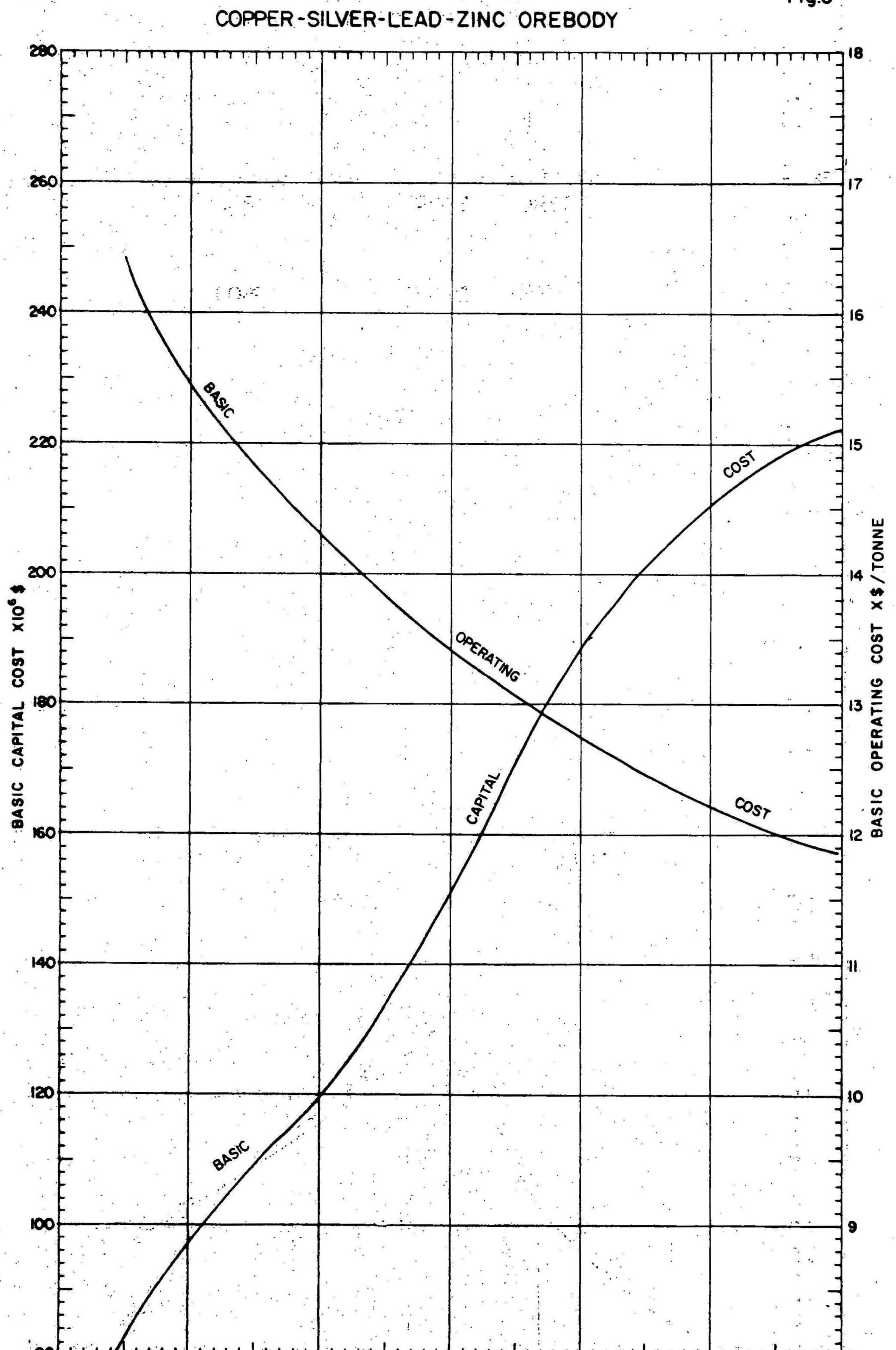

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Fig. 6

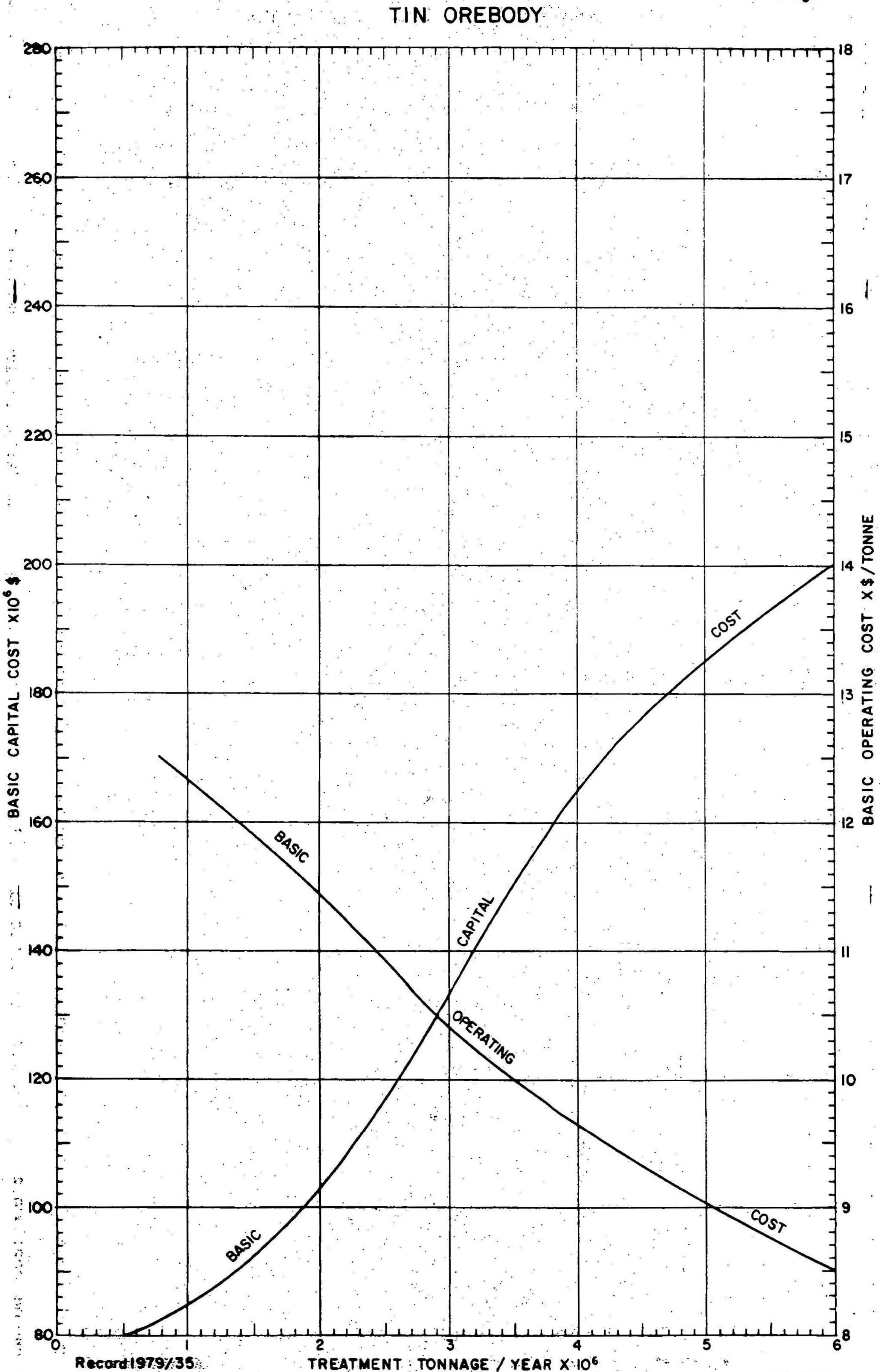
TIN OREBODY
BASIC CAPITAL COST X10⁶ $
BASIC OPERATING COST X $/TONNE
TREATMENT TONNAGE / YEAR X 10⁶
BASIC CAPITAL COST
BASIC OPERATING COST
280
260
240
220
200
180
160
140
120
100
80
18
17
16
15
14
13
12
11
10
9
8
0
1
2
3
4
5
6

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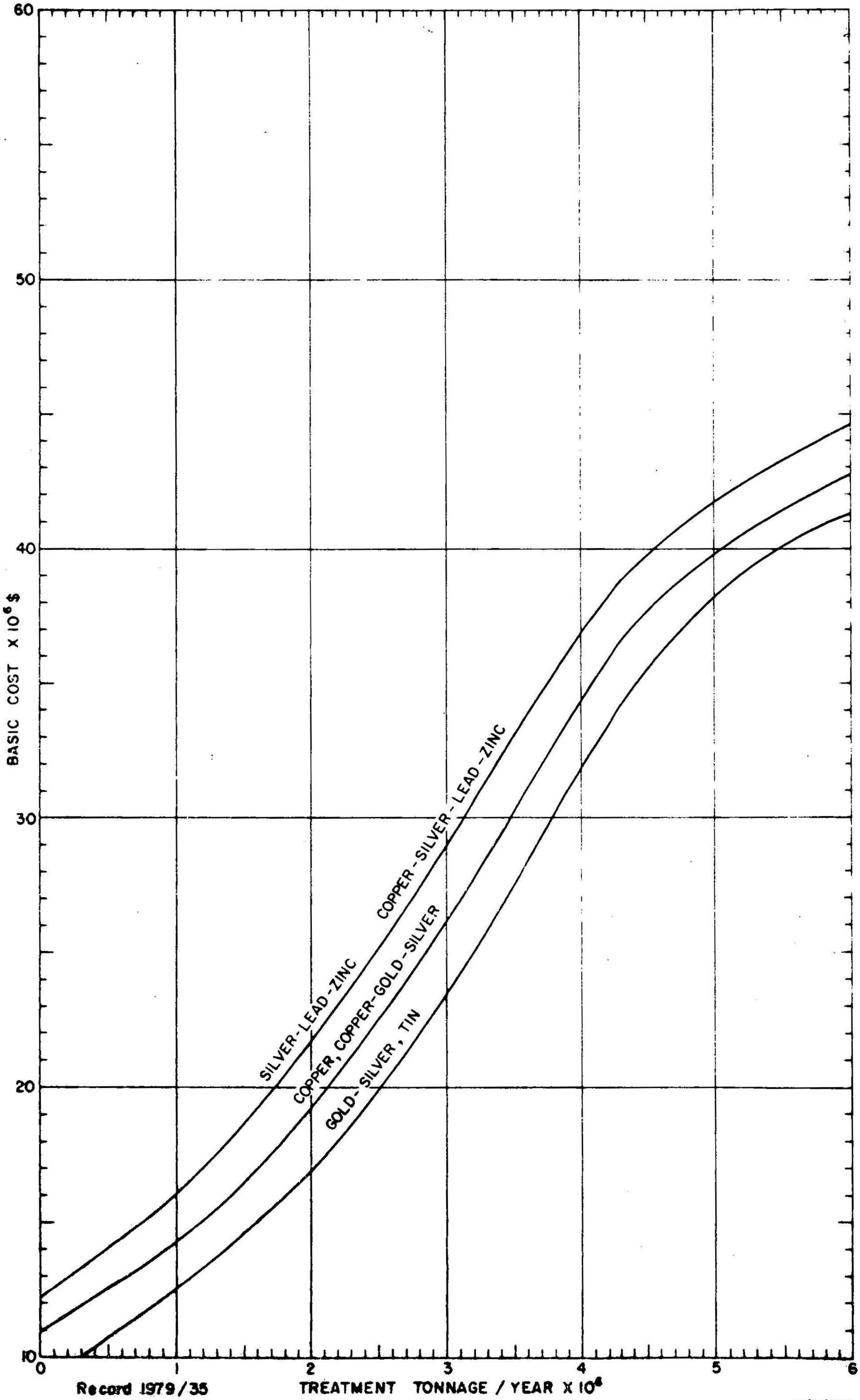
Fig. 7

BASIC TOWNSHIP COST

(Takes account of varying personnel requirements for mining and concentrating)



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