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THE ECONOMIC VIABILITY OF DEEP-SEABED MINING OF POLYMETALLIC NODULES

by

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(This manuscript has been submitted to the United Nations to be printed as a working paper for the Preparatory Commission for the International Sea-Bed Authority and for the International Tribunal for the Law of the Sea.)

ABSTRACT

This study evaluates the profitability of mining polymetallic nodules from the deep seabed in the northeast Pacific Ocean. Two hypothetical operators are considered -- an Australian company, assumed to be paying a production charge to the International Sea-Bed Authority (ISA) and The Enterprise (the autonomous mining arm of the ISA), assumed not to be paying any charges.

The capital and operating costs for an operation with a capacity of 3 million tonnes (Mt) of nodules (dry) per year for a production life of 20 years and a preproduction period of 11 years were estimated from published material. The details of the operation are: (i) two mining ships, each with a hydraulic mining system, (ii) three ships for transportation of nodules from the mine site to a port on the west coast of the United States (USA), (iii) a Cuprion-process plant to extract nickel, copper and cobalt, and (iv) an add-on ferromanganese-process plant to concentrate manganese-rich waste from the Cuprion process and produce ferromanganese.

The cost estimates also include (i) initial and ongoing exploration, (ii) research and development of mining and extraction technology, and (iii) transport of products to market.

The prices of nickel, copper, cobalt and ferromanganese have fallen steadily over the last ten years in real terms (Table 3.6). The demand outlook for the four metals to the end of the century is that the projected small growth will be met by the present spare capacity of land-based producers. The outlook for prices is that no change is expected in real terms apart from nickel which may increase in the long term. With the present outlook, it was decided to use the average metal price for the month of March 1985 for calculations of revenue. The cost estimates have been made in March 1985 US dollars.

The profitability of the mining operations has been evaluated by calculating the discounted cash flow rate of return (DCFROR). For such a high-risk venture to be viable, it is considered that a DCFROR of 18% or greater would be required to attract the necessary investment capital. The calculated DCFROR for The Enterprise was less than 1%, based on point estimates for costs, unit price and grade. The revenue from the four metals totals \$192/t of nodules recovered. For a DCFROR of 18% to be reached, the revenue per tonne would have to rise to \$366. This would require the aggregate metal prices of the products to double.

Point estimates for costs, unit price, and grade give no indication of the uncertainty of the estimate. Thus, for each parameter, a range was estimated in which the actual value is likely to be found. DCFROR calculations were carried out using sample values randomly selected by the Monte Carlo simulation procedure. These calculations were done using the US Bureau of Mines mine simulation (MINSIM) computer program.

The ranges of results, given in Table I below, provide an indication of the expected DCFROR values. The results show that no forecast DCFROR exceeds 4%, which is well below the target DCFROR of 18%. It is noted from Table I that the Australian company, paying taxes and production charges to the ISA, is less profitable than The Enterprise.

The alternative extraction processes do not improve profitability.

The conclusion is that, given the present metal price outlook, deep seabed mining for polymetallic nodules is unlikely to be undertaken on a commercial basis for the foreseeable future.

TABLE I. DEEP-SEABED MINING: SUMMARY OF DISCOUNTED CASH FLOW RATES OF RETURN (DCFRORs) FOR THE TWO HYPOTHETICAL OPERATORS

Simulation	Range		
	upper	mean	lower
The Enterprise with full equity	+4%	2%	- 1%
The Enterprise with full equity and loan repayments made for equity borrowed	0%	- 3%	- 7%
The Enterprise with half equity and loan repayments made for half equity borrowed	+4%	1%	- 3%
Australian company (before tax)	+2%	0%	- 4%
Australian company (after tax)	+1%	- 1%	- 5%
The Enterprise (with full equity) using the pyrometallurgical process	0%	- 3%	- 9%
The Australian company (before tax) using the pyrometallurgical process	-4%	-14%	-40%
The Enterprise (with full equity) using the reduction ammonia leach process	+3%	0%	- 3%
The Australian company (before tax) using the reduction ammonia leach process	-1%	- 5%	-13%

Contents

4

Figures

Tables

5

6

1. INTRODUCTION

The discovery of polymetallic nodules on the ocean floor has led to research into the development of mining methods and processes for the mining and recovery of nickel, copper, cobalt and manganese from these nodules. To date, no mining on a production scale has started, owing mainly to the adverse market that prevails for these metals.

The Bureau of Mineral Resources, Geology & Geophysics (BMR) undertook this study in order to evaluate the profitability of mining nodules from the deep-seabed, and to assess the likelihood of any ocean mining in the near future.

After a review of published reports on deep-seabed mining, it was decided that a hypothetical mining operation with a capacity of three million dry tonnes of polymetallic nodules per year (polymetallic nodules in their natural state contain about 30% water by weight) would be considered, for the extraction of nickel, copper and cobalt and manganese in the form of ferromanganese. The area of the ocean floor that is considered to be of highest value in terms of metal grade and nodule abundance is the northeast Pacific Ocean, around 126° west, 15° north, between the Clarion and Clipperton Fracture Zones. The mining operation would be based, on the west coast of the USA where the processing plant would be located.

The hypothetical mining venture considered in this study is assumed to be Australian-owned. The venture would be required to pay a production charge to the International Sea-Bed Authority (ISA) and also pay Australian taxes. No charges that would be payable to the USA are considered in this study.

It is envisaged that, under the United Nations Convention on the Law of the Sea, the Australian mining venture will be mining alongside the mining arm of ISA, The Enterprise. Thus, the likely profitability of The Enterprise is considered in detail also.

2. COST ESTIMATION

The study was based on published cost estimates. As mentioned, there is no mining of nodules to date and so all the cost estimates are founded on the assumption that satisfactory mining and processing systems will be developed. The costs were escalated to March 1985 US dollars using published US indexes (Appendix 1).

2.1 Exploration costs

Detailed exploration of the resource will be required before a decision is taken to build the mining ships, transport ships and process plant. This will require ship charter, for a survey by marine geologists, to make a detailed evaluation of reserves. The exploration will have to determine (1) the areal variations in the abundance of the nodules, (2) the areal variability of the grade of all four metals, and (3) the topography of the mining surface.

The six-year exploration program of Hillman & Gosling (1985) is used in this study and their cost of $21.0 million (1983 US$) was escalated to $21.1 million. The indexes used for this escalation and their weighting were unskilled labour (25%) (equivalent to mining labour in Appendix 1), skilled labour (20%) (equivalent to construction labour in Appendix 1), fuel (30%) and transport (25%). The calculation for each index was:

$$\frac{\text{March 1985 index}}{\frac{1}{2}(\text{average 1982 index} + \text{average 1983 index})} \times \text{percentage}$$

The Enterprise is assumed to carry out all its own exploration. (It is noted that The Enterprise can request registered pioneer investors to carry out the exploration on its behalf under the Law of the Sea Convention, resolution II, paragraph 12(A)(i).)

2.2 Mining costs

The size of the operation was fixed at 3 million dry tonnes of polymetallic nodules per year as several authors (Shaw, 1976; Nyhart, 1983; Flipse, 1982; Hillman, 1983, and Hillman & Gosling, 1985) used this capacity of operation to do their economic evaluations of deep-seabed mining. No other size of operation was considered in this study.

The mining operation is carried out by a collector that progresses along the ocean floor. The collector has the capability to discharge some of the fine sediment collected with the nodules. The collector is connected to the mining ship by a pipe through which the nodules are pumped to the surface in a slurry. The mining ship has further screening facilities to remove any remaining fines before the nodules are stored in the ship. The mine ship is designed with a storage capacity the same as that of the ships that transport the nodules to the port.

Two mining ships will be required. Each will work 300 days per year (allowing 40 days for maintenance and unsuitable weather), and 20 hours' production time per day (Hillman, 1983), at 94% efficiency. This gives an overall utilisation of the mining system of 78%; this may be high, but Andrews & others (1983) and Hillman (1983) consider it can be achieved.

The collector has the same characteristics as that used in the study by Hillman (1983). A 10 m collector working at 90% dredge efficiency (the ratio of the quantity of nodules recovered by a collecting device to the quantity of nodules available in the dredge path; Pasho, 1979) is considered, travelling at 1 m/s. At an average abundance of nodules of 8.2 kg/m^2*, the average production will be 266 t/hour. The parameters of the mining field (i.e. abundance and metal grades) are detailed under Revenue (3.1).

The mine ships will have the capacity to store nine days' production, i.e. about 70 000 t; they will be of the 100 000 d.w.t. class, with modifications to allow for mining as detailed in the cost estimates below.

2.2.1 Capital costs

The costs are estimated for one mine ship and doubled for the two ships:

1. Mine ships

A. Basic ship. The basic ship of 100 000 d.w.t. class is estimated to cost $24.5 million from Japanese shipyards (Department of Transport, personal communication, 1985).

The items B to E are taken from Flipse (1982) and escalated to March 1985 US$ by indexes mentioned in the text.

B. Hull modifications. The cost of $5.2 million (1980 US$) was escalated for skilled labour (50%) and steel (50%) indexes, giving $6.6 million. This allows for several modifications including a moon pool to enable the collector and pipes to be lowered from the centre of the ship where there is least effect by wave motion.

C. Machinery modifications. The cost of $8.8 million (1980 US$) was escalated for skilled labour (60%), steel (20%) and equipment (20%) indexes. This gives a cost of $11.5 million.

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* This abundance was used by Hillman (1983). The figure was reached by averaging all the abundance figures obtained from samples. The pumping capacity used for the hydraulic lift will limit the flow rate to 648 t/hour, which equates to an abundance of 18 kg/m^2. This means that all abundances over this figure may have to be reduced to 18 kg/m^2 for calculation of average abundance as the mining system may not handle greater abundances. Andrews & others (1983) mention that the collector will be designed to allow for variations in abundance by having storage capacity; but this would only allow for variations over short distances.

9

D. Navigation and communications. The cost of $0.9 million (1980 US$) was escalated to $1.1 million for extra equipment (equipment index 100%), required so that the ship can accurately steer the collector through the mining area.

E. Special hotel and shops. The cost of these items, of $2.0 million and $1.4 million respectively (1980 US$), was escalated for skilled labour (50%), equipment (25%) and steel (25%) indexes. These items are required for the mining crews and ship crews who will be required to be on board the mine ships for a 30-day stretch before relief. The escalated cost is $2.6 million and $1.8 million for the hotel and shops respectively.

	$million
A. Mine ship	24.5
B. Hull modifications	6.6
C. Machinery modifications	11.5
D. Navigation & communication	1.1
E. Special hotel	2.6
F. Shops	1.8
	48.1 x 2 = 96.2

2. Handling and storage facilities for the mining and ore handling equipment

The handling and storage facilities include a derrick to raise and lower the 4000--5000 m of pipe and storage for all the pipe on board ship. A spare collector is also required to be stored. The ore handling system consists of: (1) equipment to transfer the nodule slurry from the vertical pipe to a separator where sea water is returned to the sea and the nodules put onto a conveyor; (2) the conveyor system which transfers the nodules to the storage; and (3) equipment for the reclaiming and transfer of nodules onto the transport ships in slurry form. The fuel transfer equipment from the transport ship to the mining ship is included in this cost. Hillman & Gosling (1985) estimate the cost of this equipment as $87.1 million (1983 US$) for the two ships. This is escalated for skilled labour (65%) and steel (35%) indexes, to give a cost of $93.5 million.

3. Pumping system

The pumping system would include multi-stage submersible pumps supplied with electricity from a cable alongside the pipe. The cost of these pump systems was estimated by Flipse (1982) and Andrews & others (1983) as $11.8 million in 1980 US$ and $13.8 million in 1982 US$. Hillman (1983) estimated the cost as \$13.0 million in 1981 US\$ and Hillman & Gosling (1985) estimated \$14.85 million in 1983 US\$. The rate of increase of these costs is more in line with the US Consumer Price Index (CPI) than with any other index, and so the CPI was used to escalate the estimate of Hillman & Gosling (1985) to \$16.15 million for each mining ship, i.e. \$32.3 million for both.

4. Dredge pipes and bottom hoses

The dredge pipe is required to be in manageable lengths of about 12-13 m, with internal diameter of about 40 cm, Hillman (1983). The pipes would be painted outside with inorganic zinc and coated inside with an abrasion-resistant material (Flipse, 1982). The pipes would have stand-offs to allow the electric cables to be attached. There would be special sections for mounting the pumps. Each ship would have one set of dredge pipes, while a third would be stored at the base port. It is mentioned by Flipse (1982) that any major damage or loss of the pipe string would cause other damage, requiring a return to the base port for repairs. The estimate of Flipse (1982) of \$13.4 million (1980 \$US) for each string was escalated for steel (60%) and skilled labour (40%) indexes, giving a cost of \$16.7 million. The flexible hose at the bottom of the string, which connects to the collector, is estimated by Flipse (1982) to cost \$1.4 million (1980 US\$). This is escalated for industrial materials (80%) and skilled labour (20%) indexes to give \$1.7 million. For the two ships, the total cost equals 16.7 x 3 + 1.7 x 4 = \$56.9 million.

5. Collector

The collector, as mentioned, is required to reject large boulders but accept nodules and sediment. However, the fine sediments are removed before the nodules are transported to the mine ship, to reduce the total material pumped. The collector has to be designed to rest on the sediments, which have average vane shear strengths of 20 g/cm^2 at the sediment surface to 100 g/cm^2 at 15 cm depth (Hillman, 1983). The collector is required to maintain very high levels of availability, as it is estimated by Hillman (1983) to take between four and five days to lower the collector to the ocean floor.

The cost estimates for the collector by Flipse (1982), Andrews & others (1983), Hillman (1983) and Hillman & Gosling (1985) are similar if it is assumed that Hillman's estimate includes a spare collector for each ship for the \$7.5 million. There is an approximate increase in cost of \$0.5 million per year from the Flipse (1982) estimate to that of Hillman & Gosling (1985). The cost estimate for two collectors for each ship is thus \$8.5 million.

6. Start-up costs

These costs are based on the requirement that modifications to steelwork will be necessary in the early stages of mining. The estimate of Hillman & Gosling (1985) of $23.2 million (1983 $US) was escalated for skilled labour (50%), steel (30%), unskilled labour (10%) and equipment (10%) indexes, to derive a figure of $24.8 million.

Total mine capital costs	$ million
2 mine ships	96.2
Handling and storage/ore handling	93.5
Pumping system	32.3
3 pipe systems, 4 hoses	56.9
Collectors (incl. spares)	8.5
	287.4
Start-up costs	24.8
TOTAL	$312.2

It is assumed that the costs will be equally distributed over the six years of construction and that the start-up costs are added to the sixth year. This gives $47.9 million per year for the first 5 years, and $72.7 million for the sixth year.

2.2.2 Annual operating costs

1. Crew costs.

Each ship's crew is expected to number 40 and each mining crew 32. The crews are required to have relief, and so two ship's crews and two mining crews are needed for each ship. The cost estimate of Hillman & Gosling (1985) of $21.3 million was escalated with the unskilled labour index to $22.8 million.

2. Subsistence.

This provides for food and miscellaneous supplies for the crews on the two mining ships. The Hillman & Gosling (1985) figure of $2.0 million was escalated, using the CPI, to $2.2 million.

3. Maintenance and repairs.

These expenses are based on a percentage of the capital costs.

A. Mining ship. Estimated as 2% of the capital cost (Flipse, 1982).

B. Pipestring and collector. Hillman (1983) uses the estimate of Shaw (1976), that a 6--12 month life for the collector and pipestring can be expected, whereas Flipse (1982) estimates twice this. For this estimate a

12

hypothetical pipestring life of 18 months is used to allow enough funds for repairs/replacement. This gives an annual repair bill of 66% of the capital cost of two pipestrings and two collectors with hoses. (It is noted that a pipestring life of 18 months is impractical, because replacement will require the mine ship to return to port at different times of the year.)

C. Other mining and transfer gear. Estimated as 5% of capital cost (Flipse,1982).

Thus, annual cost of maintenance and repairs is as follows ($ million):

A.	2% x 96.2	= 1.9
B.	66% x 41.05	= 27.3
C.	5% x 125.8	= 6.4
	TOTAL	35.6

4. Insurance.

This is based on the estimate by Hillman & Gosling (1985) of $6 million (1983 US$) and escalated using the CPI to give $6.5 million.

5. Fuel.

It is estimated by Flipse (1982) that 46 600 long tons (47 350 t) of fuel oil would be used by the two mining ships each year; Hillman (1983) estimates 51 000 t. For this estimate, 50 000 t is used, at a cost of $190/t. This gives $9.5 million.

6. Lubrication.

This is estimated as $0.1 million in line with Flipse (1982) and Hillman (1983) (escalation can be disregarded for this small amount).

7. Exploration and research & development.

The continuing exploration of the mining site is considered as a mine operating cost. This work is necessary in evaluating the mining area for the year ahead so that mining plans can be made. A chartered ship would be used in collecting the samples of the ocean bottom and mapping the topography. As the collector is such an essential item of the mining operation, it is imperative that research and development proceeds on the collector and the other mining operations. The estimate by Hillman & Gosling (1985) of $6.4 million was escalated for unskilled labour (25%), skilled labour (20%), fuel (30%) and transport (25%) indexes, but this does not escalate the cost significantly and so $6.4 million is used.

8. General administration.

For the Australian company this is estimated to be 5.5% of the operating cost, i.e., $4.6 million. For The Enterprise it is estimated as 10% (i.e., $8.3 million), on the basis that The Enterprise will be putting emphasis on training and will need to establish a personnel section, etc., whereas the Australian company will already have a personnel section, etc. that can be enlarged at a lower cost than setting up a new section.

9. Environmental costs.

It will be necessary to monitor the plumes put out by the mining ship and by the collector. In this paper it is assumed that this monitoring of the environment (biological, chemical, geological and physical) will start with the production phase. However, it may be necessary to start monitoring before production if the mine operators are to provide an Environmental Impact Statement prior to being given permission to start mining. At present, there are no regulations under the Law of the Sea Convention stating the legal obligations of mine operators. The equipment required for this monitoring is purchased under capital expenditure (see section 2.5.2 on Environmental Capital Costs), but the operation of retrieving the monitoring instruments each year and placing new sets on site is covered here. The monitoring will include the charter of a research vessel for retrieving and placing monitoring devices, on-hand analysis and report writing. Andrews & others (1983) cover this subject in detail and estimate the monitoring to cost $1.5 million per year (1980 US$). This is escalated by the skilled labour index to $1.7 million.

Total annual mine operating costs	$ million
1. Crew costs	22.8
2. Subsistence	2.2
3. Maintenance and repair	35.6
4. Insurance	6.5
5. Fuel	9.5
6. Lubrication	0.1
7. Exploration and R&D*	6.4
Sub-total	83.1
8. Australian company gen. exp.	4.6
9. Environmental monitoring	1.7
TOTAL	89.4
8. Enterprise gen. exp.	8.3
9. Environmental monitoring	1.7
TOTAL	93.1

14

* The cost of this item will be zero in the last year of production.

This is equivalent to $29.8/t of nodules (dry) for the Australian company and $31.03/t for The Enterprise.

2.3 Transportation costs

The transport of nodules from the two mining ships to the US west coast will be by three bulk/ore carriers of the 70 000 d.w.t. class. The various details for the ships are similar to those used by Hillman (1983):

Transport distance	3410 km
Speed, laden	27.0 km/hr
unladen	31.0 km/hr
Cycle time, laden to port . .	5 days 6 hours
unladen from port . .	4 days 14 hours
port . .	1 day 21 hours
loading at sea . .	1 day 8 hours
Total	13 days 1 hour
Load per trip (90% capacity) . .	64 000 t (wet)
Production* . .	300 days/year
Trips per vessel per annum . .	23
Total number of ships . .	3
Crew size	28
Fuel and lubication consumption	
at sea . .	39 t fuel oil/day
	3 t diesel oil/day
at port . .	one-tenth 'at sea' consumption.

* The mining ships are assumed to have a realistic production capability of 300 days for the year. With a storage capacity equivalent to approximately 9 days, production on each mining ship, transportation would be required on less than 300 days, but there may be problems with scheduling the three transport ships with the two mining ships. For this study, 23 round trips per vessel has been assumed, which allows for some flexibility. It is noted that the loading time of the ship at sea could be reduced by improved techniques and more slurry lines between the mining ship and transport ship. This would allow more time in port.

2.3.1 Capital costs

1. Three 70 000 d.w.t. bulk/ore transport ships

These are assumed to be built in Japanese shipyards, where a 70 000 d.w.t. class bulk/ore ship cost \$17.5 million at September 1984 (source: Lloyd's Shipping Economist). The current price trend is downwards (\$16.0 million at December 1984, same source). The estimate for this study is taken as \$17.5 million per ship, i.e. \$52.5 million for the three transport ships.

2. Slurry handling system.

Each transport ship will be required to have equipment that can pump the slurry from the mining ships. Dewatering pumps will also be required to drain the holds of the transport ships once the slurry is placed. The transport ships will not need to re-slurry and unload the nodules; this will be done by re-slurrying and pumping-out equipment at the slurry terminal port. Andrews (1978) estimated that the slurry loading and dewatering equipment for each ship would cost \$1.22 million (1977 US\$). This cost is escalated for the same indexes as the ore handling equipment on the mine ship, i.e., for skilled labour (65%) and for steel (35%). This gives a cost for the three ships of \$2.04 million x 3 = \$6.1 million.

3. Upgrading of transport ship.

There will be special, additional, facilities on the transport ships, such as extra berths for the relief crews of the mining ships. The cost estimated by Andrews (1978) of \$5 million allowed for 'Oriental Diesel' ships to be upgraded to pass United States requirements. However, this cost may be too high, because the standard ship from a Japanese shipyard may already meet several of the requirements. The cost estimate of \$5 million is escalated for skilled labour (50%), steel (30%) and equipment (20%) indexes to \$8.43 million for each ship. Total \$25.3 million.

4. Supply boat.

A long-range, high-speed, boat is allowed for in the estimate, to take supplies to the mining ships. Hillman (1983) estimates the cost of the boat to be \$1.4 million (1981 US\$) and Hillman & Gosling (1985) \$1.5 million (1983 US\$). It is estimated to be \$1.6 million for this study.

Total transport capital cost	\$ million
1. Three 70 000 d.w.t. ships	52.5
2. Three slurry handling systems	6.1
3. Upgrading	25.3
4. Supply boat	1.6
	85.5

16

It is assumed that the construction of the three ships will take six years and the construction of the supply boat the last two years of the six-year period.

2.3.2 Annual operating costs

1. Wages and benefits

The cost estimate by Hillman & Gosling (1985) of $4.7 million (1983 US$) was for a US crew of 32. Australian crew costs are similar. The cost of $4.7 million was escalated by the unskilled labour index to $5.0 million.

For items 2 to 4 and 7 to 8 below, the Hillman & Gosling (1985) estimates in 1983 US dollars were used for this study and escalated by the various indexes mentioned.

2. Subsistence

The estimate of $0.5 million for food and supplies was escalated with the CPI but this produced an insignificant increase and so $0.5 million was used.

3. Maintenance and repairs

The estimate for ship maintenance and repairs of $6.2 million was escalated by the skilled labour (50%), equipment and parts (30%) and steel (20%) indexes, to give $6.6 million.

4. Insurance

The estimate of $1.4 million for the insurance of the three transport ships and the supply boat was escalated using the CPI (100%) to $1.5 million.

5. Fuel and lubrication

The fuel consumption rate used, as detailed above, was 39 t of fuel oil and 3 t of diesel oil per day at sea and one-tenth of the 'at sea' consumption in port. For the 23 trips of the 3 ships at a cost of $190/t for fuel oil and $300/t for diesel oil, this gives a cost of $6.5 million.

6. Port charges

The average port charge of $20 000 per visit, as supplied by the Department of Transport (1985), was used. The total estimate for the year is $1.3 million.

7. Helicopter

The cost of leasing and operating a helicopter was estimated at $0.7 million and escalated to $0.8 million.

8. Supply boat

The operation of this boat with crew, fuel and supplies was estimated to be $1.8 million. This was escalated by the unskilled labour (50%), equipment (30%) and fuel (15%) indexes to $1.9 million.

9. General administration

The same percentages of operating costs were taken as in the mining overhead costs, i.e., 5.5% for the Australian company, and 10% for The Enterprise of operating costs ($1.3 million and $2.4 million respectively).

Total transport operating costs	$ million
1. Wages and benefits	5.0
2. Subsistence	0.5
3. Maintenance and repairs	6.6
4. Insurance	1.5
5. Fuel and lubrication	6.5
6. Port charges	1.3
7. Helicopter	0.8
8. Supply boat	0.9
Sub-total	24.1
9. Australian company, gen. admin.	1.3
Total	25.4
9. The Enterprise, gen. admin.	2.4
Total	26.5

This is equivalent to $8.47/t of nodules (dry) transported for the Australian company and $8.83/t for The Enterprise.

2.4 Processing and other land-based costs

The composition of polymetallic nodules is such that the contained copper, nickel or cobalt cannot be liberated simply by physical beneficiation. This is because the metals do not occur in the usual ore minerals, but are disseminated in the manganese and iron oxides that make up most of each nodule. The porosity of the nodules is high, with a surface area of 200 m^2/g (King & Pasho, 1979), leading to a water content of about 30% by weight.

The process considered in this study is the Cuprion process, developed by Kennecott Copper Corporation, as detailed by Hillman (1983). The Cuprion process and others that have been developed to date are listed in Table 2.1 and the processes not fully developed are listed in Table 2.2

The Cuprion hydrometallurgical process uses an ammoniacal solution containing cuprous ions to extract copper, nickel and cobalt from the manganese and iron oxides. The copper and nickel are recovered from the solution by ion exchange and electrowinning to produce copper and nickel 18 cathodes. The cobalt is recovered from the solution by precipitation with hydrogen sulphide. The cobalt is then washed, dried and sold as a powder; the ammonia is recovered from solution and recycled (Figure 2.1). For the four-metal recovery, an add-on manganese recovery plant is assumed that produces ferromanganese. The carbonate tailing from the leach process would be put through flotation cells with additives; then put through a kiln to give a synthetic manganese oxide ore of 55--60% manganese. The ore would then be put in a furnace with fluxes and iron ore to give a ferromanganese product containing 78% manganese.

The recoveries assumed for the four metals are based on Hillman (1983) as the add-on ferromanganese plant and Cuprion method are considered in his study (Table 2.3).

TABLE 2.1. CONVENTIONAL PROCESSING TECHNOLOGIES*

Process	State of development
Reduction ammonia leach process	Equivalent module
Cuprion process	Pilot plant
Pyrometallurgical process	Equivalent module
Hydrochloric acid leach process	Pilot plant
Sulfuric acid leach process	Pilot plant

* Conventional processes are defined as those that have either undergone significant bench-scale and pilot-plant testing or are based on a process currently in operation. For instance, the reduction ammonia leach process is based on the Nicaro process developed for lateritic ores. Thus, it has an equivalent industrial module.

Source: Arthur D. Little, Inc.

TABLE 2.3. METAL RECOVERIES IN CUPRION/FERROMANGANESE PROCESSING

	Recovery (%)
Cobalt	65
Copper	92
Manganese	44
Nickel	92

TABLE 2.2. OTHER PROCESS OPTIONS

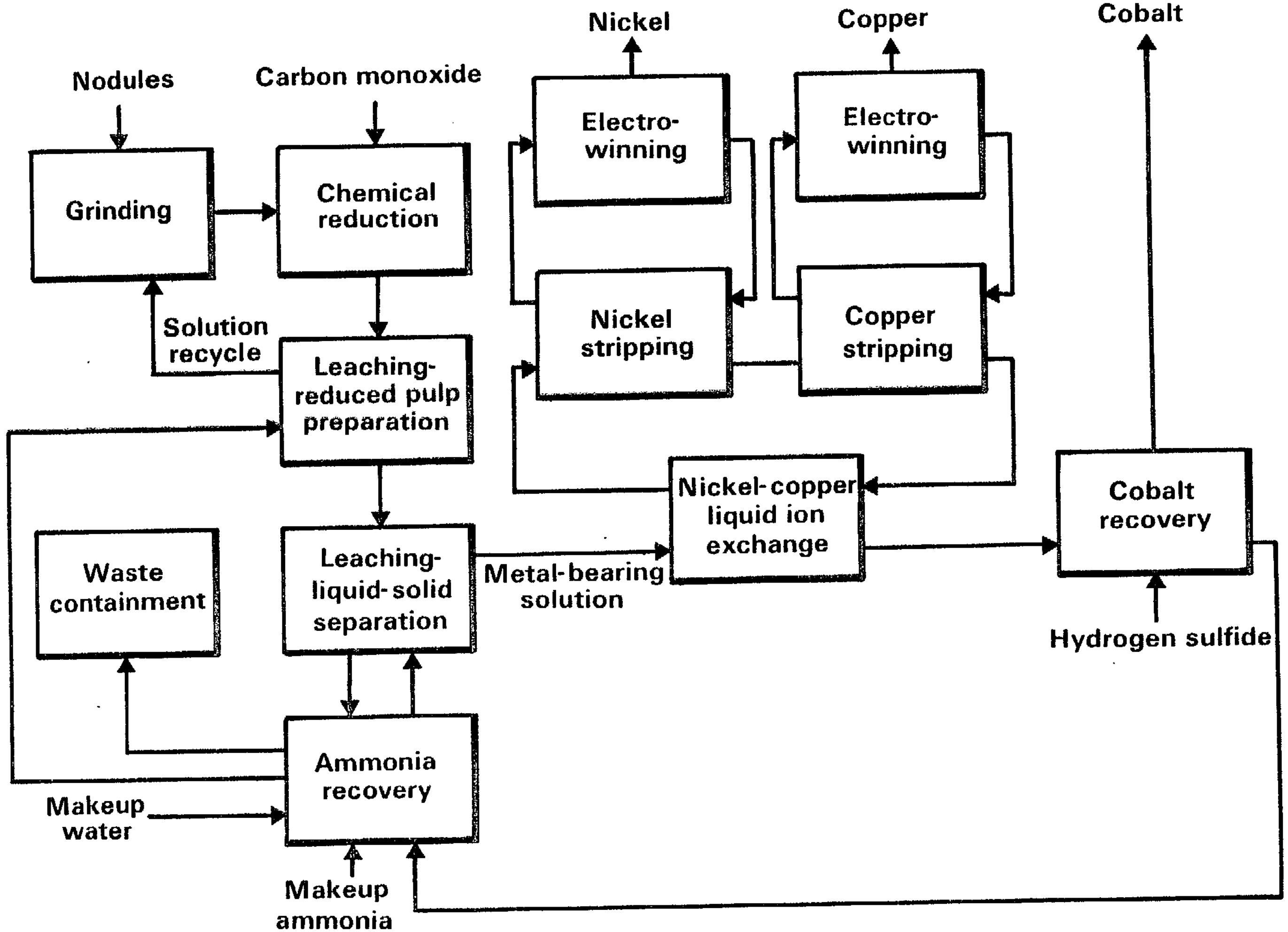
Process type	Source[1]	Patent assignee(s)	State of development[2]	Process concept[3]
SO_2 process (sulfurous acid)	Literature (10)	Bu Mines/Univ. of Hawaii	Lab	Flowsheet developed
Nitrous/nitric acid	Literature (2)	Chemetals, Inc.	Lab	Flowsheet developed
Oxalic acid	Literature (2)	Univ. of Hawaii Univ. of Arizona	Lab	Inferred
Adsorbing colloidal flotation	Literature (2)	Univ. of Hawaii Univ. of Arizona	Lab	Inferred
Plasma technology	Literature (1)	Not assigned	Conceptual	Inferred

1 Number of post-1977 references indicated.

2 Lab = Laboratory/bench-scale tests.

3 The overall process concept and flowsheet can be either developed from literature or inferred from similar processes and technologies.

Source: Arthur D. Little, Inc.



(After U.S. Bureau of Mines, IC 8924, Haynes & others, 1983)

Fig. 2.1 CUPRION PROCESS

15/219

2

2.4.1 Capital costs

The cost estimate of the Cuprion plant, 'add-on' ferromanganese plant, slurry terminal and slurry pipeline is based on the Hillman & Gosling (1985) estimate and has been escalated from January 1983 US dollars to March 1985 US dollars, with various indexes mentioned. The only variations to the cost estimate of Hillman & Gosling (1985) are (1) the capital-related expenses for the operating cost estimates (i.e. maintenance, materials and insurance) which are based on a percentage of total capital expenditure from Flipse (1982), and (2) the general expenses for The Enterprise which is 10% as for the other sections. No allowance has been made for possible additional capital costs related to infrastructure and town site. It is assumed that these are already available at the site of the process plant.

2.4.1.1 Cuprion process plant

1. Plant and equipment

The cost estimate for construction of the plant plus purchase of equipment was $370.3 million. This is escalated for skilled labour (40%), construction material (40%) and steel (20%) indexes to $394.5 million.

2. Utilities and services

The cost estimate of $159.1 million for construction of the utilities and services was escalated for purchased equipment (70%), skilled labour (17%) and construction materials (13%) indexes to $167.0 million. This includes the construction of a coal fired power generation unit for the Cuprion plant, the exhaust gases being used in the process (carbon monoxide, carbon dioxide).

3. Waste disposal (dams, etc.)

The cost estimate of $30.3 million for construction of waste disposal dams, was escalated for skilled labour (58%), fuel (25%), tyres (15%) and construction materials (2%) indexes to $30.5 million. (These escalation factors were taken from the Capital & Operating Cost Estimating System Handbook, Mathews, 1977), on earth-fill dikes and small-dam construction.)

4. Waste disposal (pipelines, etc.)

The cost estimate of $20.9 million for the construction of waste disposal pipelines, pumps, etc. and land acquisition for disposal area was escalated to $22.3 million. Land acquisition was assumed to be 10% of the capital cost and was escalated using the CPI. The remainder was escalated for purchased equipment (56%), steel (28%) and skilled labour (16%) indexes.

22

5. Railway spur and access road

The cost estimate of $5.7 million for building the railway spur and access road, each 8 km long, was escalated for steel (29%), construction materials (20%), skilled labour (20%), timber (20%), fuel (6%) and tyres (5%) indexes to $5.9 million.

6. Land acquisition

The cost estimate of $2.6 million for land acquisition for the plant was escalated with the CPI to $3.2 million.

Total capital cost for Cuprion plant	$ million
1. Plant and equipment	394.5
2. Services and utilities	167.0
3. Waste disposal (dams, etc.)	30.5
4. Waste disposal (pipelines, etc.)	22.3
5. Railway spur and access road	5.9
6. Land acquisition	3.2
	623.4

2.4.1.2 Ferromanganese plant

1. Plant and equipment

The cost estimate of $129.6 million for the ferromanganese plant, including flotation cells, kiln and electric furnace, was escalated by the same indexes as for plant and equipment for the Cuprion process plant, to $138.1 million.

2. Utilities and services

It is assumed that the power for this plant is purchased from a nearby power station. The cost estimate of $31.1 million includes the water supply, power reticulation and other service connections. It was escalated by the same indexes as for the same item in the Cuprion plant to $32.6 million.

Total capital cost for ferromanganese plant	$ million
1. Plant and equipment	138.1
2. Utilities and services	32.6
	170.7

2.4.1.3 Slurry terminal

A facility will be needed for re-slurrying and unloading the nodules at the slurry terminal port, together with adequate storage prior to pumping to the process plant. The transport ships would also take on

23

supplies; but it is assumed that fuel bunkering would be done from a barge and no fuel storage facilities would be required at the terminal. The cost estimate of $40.8 million was escalated for skilled labour (40%), construction materials (30%) and equipment (20%) indexes and for CPI (10%) to $44.2 million.

2.4.1.4 Slurry pipeline

This item includes the purchase of land between the terminal at the coast and the process plant, assumed to be 40 km away, and the slurry pipelines with pump stations. The cost estimate of $20.7 million was escalated for steel (40%), skilled labour (30%), equipment (20%), construction materials (5%) indexes and for CPI (5%) to $22.1 million.

Total capital cost for all land-based items		$ million
2.4.1.1	Cuprion process	623.4
2.4.1.2	Ferromanganese plant	170.7
2.4.1.3	Slurry terminal	44.2
2.4.1.4	Slurry pipeline	22.1
		860.4

2.4.2 Annual operating costs

2.4.2.1 Cuprion plant, slurry terminal and slurry pipeline

1. Wages and benefits

The cost estimate of $18.6 million for the wages and benefits of operators of the Cuprion plant is escalated for the unskilled labour index (100%) to $19.9 million.

2. Materials and supplies

The cost estimate of $4.0 million for the process materials and supplies such as chemicals and reagents is escalated for the industrial materials index (100%) to $4.1 million.

3. Utilities and fuel

The cost estimate of $40.5 million for utilities and fuel, such as coal, petroleum and water, is not escalated, because the costs of these items have not risen appreciably over the last two years.

4. Capital-related expenses

The cost estimate for the maintenance of the Cuprion plant, slurry terminal and slurry pipeline is taken as 4% of the total fixed capital (TFC), and for supplies as 1% of TFC. Insurance of these is also taken as 1% of TFC. The capital cost of the plant, slurry terminal and slurry pipeline is $689.7 million, and so capital-related expenses are $41.4 million (6% of $689.7 million).

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5. Waste disposal

Cost estimate $7.8 million escalated for unskilled labour (40%), construction materials (20%), equipment (15%), steel (15%), tyres (5%), and fuel (5%) indexes to $8.1 million.

6. Pipeline to waste disposal

The cost estimate of $2.7 million for the maintenance, operating and repair of the pipeline from the process plant to the waste disposal site is escalated for skilled labour (60%) and equipment (40%) indexes to $2.9 million.

7. Slurry pipeline

The cost estimate of $6.5 million for maintenance, operating and repair of the 40-km pipeline from the port terminal to the processing plant, is escalated for the same indexes as item 6, to $6.9 million.

8. Unload and store

The cost estimate of $3.1 million for the unloading and storing of nodules at the port terminal, including maintenance and repair, is escalated for the same indexes as the item 6, to $3.3 million.

9. Rail spur

The cost estimate of $0.2 million for the maintenance and operation of the rail spur is not escalated.

10. General administration

The overhead cost for administration is based on a percentage of operating costs. For the Australian company, the percentage is taken as 5% and for The Enterprise as 10% (the same for the overheads for transport and mining).

11. Research and development

Improvements to the process will be continually necessary, to keep the operation economically viable. The cost is estimated as $2 million. The work can be done in-house or contracted out.

Total annual operating cost for Cuprion plant, slurry terminal and slurry pipeline

	$ million
1. Wages and benefits	19.9
2. Materials and supplies	4.1
3. Utilities and fuel	40.5
4. Capital-related expenses	41.4
5. Waste disposal	8.1
6. Pipeline to waste disposal	2.9
7. Slurry pipeline	6.9

25

8. Unload and store	3.3
9. Rail spur	0.2
Subtotal	127.3
10. General administration (Australian company)	6.4
11. Research and development	2.0
TOTAL	135.7
10. General and administration (Enterprise)	12.7
11. Research and development	2.0
TOTAL	142.0

This is equivalent to $45.2/t of nodules (dry) processed for the Australian company and $47.3/t of nodules (dry) processed for The Enterprise.

2.4.2.2 Ferromanganese plant

1. Wages and benefits

Cost estimate, $32.0 million, escalated for unskilled labour (100%) to $34.2 million.

2. Materials and supplies

Cost estimate, $43.6 million, escalated for industrial minerals (100%) to $44.8 million.

3. Utilities and fuel

Cost estimate, $118.6 million for coal, power and water. Not escalated, owing to very small changes in these commodities. Power is purchased off the local electric grid.

4. Capital-related expenses

Cost estimate, $10.2 million, based on 6% of the capital expenditure, as with the other land-based plant and equipment.

5. General administration

Cost estimate as in analogous previous sections, i.e., 5% of total operating costs for the Australian company and 10% of total operating costs for The Enterprise.

Total ferromanganese plant annual operating costs

	$ million
1. Wages and benefits	34.2
2. Materials and supplies	44.8
3. Utilities and fuel	118.6

26

4. Capital-related expenses	10.2
Subtotal	207.8
5. General administration (Australian company)	10.4
TOTAL	218.2
5. General administration (The Enterprise)	20.8
TOTAL	228.6

This is equivalent to $72.7/t of nodules (dry) processed for the Australian company and $76.2/t of nodules (dry) processed for The Enterprise.

2.5 Research and development and environmental capital costs

2.5.1 Research and development capital costs

Research and development of the mining and processing operations must precede the major investment in construction. The mining operation requires development of a low-maintenance highly efficient collector and pumping system, and the processing of the nodules requires the research and development of a process from work-bench to pilot-plant stage. These costs will be capitalised, and are separate from the ongoing research and development which are allocated to operating costs because expenditure commences after the start of operations.

1. Mining research and development capital costs

These have been estimated by Hillman & Gosling (1985) as $75.3 million (1983 $US) over a seven-year program. For this study the figure is escalated for unskilled labour (30%), skilled labour (30%), equipment (20%), and steel (20%) indexes, to $80.2 million.

2. Processing research and development capital costs

The Hillman & Gosling (1985) estimate of $82.5 million is used and escalated for skilled labour (30%), steel (25%), unskilled labour (20%), industrial commodities (15%) and construction materials (10%) indexes to $87.6 million. The program is over seven years.

The total R&D cost is thus $167.8 million over seven years. Half of this amount is assumed to be expended over the first five years ($16.78 million/year) and the other half over the last two years ($41.95 million/year).

2.5.2 Environmental capital costs

The equipment required to monitor and survey the mining area is estimated by Flipse (1984) to be $3.0 million. Escalated using the Equipment and Parts index gives a cost of $3.2 million (March 1985 US$). These equipment costs 27 are expended before the first year of production and are allocated to capital. The operating costs of the environmental surveys, using these instruments, are included within the mine operating costs (section 2.2.2).

2.6 Working capital

The working capital required for the start of the production is assumed to be 125% of annual mine operating costs, 125% of annual transport operating costs and 50% of annual process operating costs. The percentage figures for mine and transport are based on Hillman (1983) and the figure for processing is from Hillman & Gosling (1985). Thus, the total working capital required for the Australian company is $320.5 million and for The Enterprise $334.6 million. In the cash flow analysis, the working capital is recovered in the last year through reduced operating costs.

2.7 Transport cost to market

It is assumed in this study that there will be a sufficient market for copper on the west coast of the United States to absorb the production, without significant transport costs. It is assumed that the other three commodities will need to be transported to warehouses in the eastern United States. The cost is calculated using the Capital & Operating Cost Estimating System Handbook (Mathews, 1977). The calculations are for transporting ore only, but it has been assumed that the transport costs for the final products will be of the same order. The average cost of all minerals quoted was used and costs indexed by the transport index.

$$\text{Cost/t/km} = 2.307 \times \text{Factor}$$

$$\text{Factor} = 5.361\ (\text{dist, km})^{-0.3646}.$$

A distance of 3 000 km is assumed, from the west coast site to the market warehouse.

$$\text{Factor} = 5.361 \times 3000^{-0.3646} = 0.289$$

$$\text{Cost/t} = 2.307 \times 0.289 \times 3000 = \$20.01.$$

This is escalated to March 1985 dollars. Cost/t = $20.01 x 2.318 = $46.39
= $46.

This estimate only covers the transport cost of product to market. A typical mining company has other costs under the category of marketing and sales, which have not been included in this study.

3. REVENUE ESTIMATION

3.1 Metal grade

The metal grades of the four metals to be recovered are taken from the Hillman (1983) study (Table 3.1). The grades are for 'CI' area which is at approximately 126°W and 15°N. The grades are determined by averaging 28 all the samples taken. There is still much uncertainty as to whether the variations in grade of the metals in the nodules are random or inversely related to the abundance of the nodules. It is assumed in this study that the grades vary randomly.

3.2 Product

With the grades of metal given above, and the metal recovery factors (see Table 2.3), the amount of metal product recovered from the 3 Mt nodules (dry)/year is as given in Table 3.2 below.

3.3 Metals outlook

3.3.1 Cobalt

Current world cobalt production for 1984 is estimated as 29 100 t (Table 3.3). Thus, production from an operation of 3 Mt of dry nodules, at 5 070 t, would be equivalent to 17% of world production. Cobalt consumption in the United States for 1984, where the nodule processing plant is sited, is estimated as 8 410 t; thus nodule production of cobalt would be equivalent to 50% of US demand. The effect of this tonnage of cobalt on the US and world markets must be considerable.

The forecast world demand in the year 2000 (excluding US) is in the range 22 700--32 700 t compared to 14 300 t in 1983 (Kirk, 1985). The forecast demand for the United States is in the range from 10 900--20 000 t in 2000 compared to 7 100 t in 1983. These growth rates of demand average 3.5% for the world and 3.9% for the United States over the next fifteen years.

TABLE 3.1. METAL GRADES OF POLYMETALLIC NODULES USED IN THIS STUDY

Metal	Grade (%)
Cobalt (Co)	0.26
Copper (Cu)	1.03
Manganese (Mn)	26.80
Nickel (Ni)	1.33

TABLE 3.2. METAL PRODUCT FROM 3 Mt OF NODULES (DRY)

Metal product	Tonnes
Cobalt	5 070
Copper	28 704
Ferromanganese (78%Mn)	453 538
Nickel	36 720

With the possibility of cobalt being substituted by other metals in alloy manufacture (albeit at a poorer performance), the price is not likely to advance any further in real terms.

Over the last year the price has stayed static, and long term price stability is expected. Any increase in demand is anticipated to be met by current capacity with little change in price.

3.3.2 Copper

Estimated world mine production of copper for 1984 was 8 274 000 t. (Table 3.4). The production from a 3 Mt dry-nodules-per-year operation would produce 28 700 t of copper, which is 0.35% of world production. This tonnage is not significant compared to the tonnages of the other metals produced in relation to world production.

The forecast growth in world demand for copper (excluding US) averages 2.7%/year, to 13.6 Mt in the year 2000, and 1.9%/year for the US, to 2.5 Mt in the same period (Jolly, 1985). The World Bank (1984) suggests lower growth for the world at 1.4% for period 1979/81 to 1995. The growth is unlikely to affect the price.

With the recent low prices, many privately owned mines have either closed as in the US or reduced the operating costs and boosted mine head grade to cater for the worst possible copper price.

As outlined by McCutcheon (1985) the effect of these mine closures has been a fall in incremental copper production. This will, McCutcheon forecasts, push up the price to $1936--$2024/t (88--92 ¢/lb) in 1985 US dollar terms, until 1990. However, this price is not expected to be sustained, because of the current substitution which is predicted to continue.

TABLE 3.3. WORLD MINE PRODUCTION OF COBALT (t)

	1981	1982(e)	1983(e)	1984(e)
Australia	2 900	3 500	2 200	2 000
Botswana(e)	250	250	270	n.a.[(a)]
Canada	2 280	1 500	1 450	2 000
Cuba(e)	1 720	1 500	1 400	2 200
Finland(e)	1 030	1 000	1 000	1 200
Morocco	790	700	-	-
New Caledonia(e)	140	500	270	300
Philippines(e)	1 000	500	450	200
USSR(e)	2 250	2 350	2 200	2 700

30

Zaire	15 500	11 300	9 100	14 000
Zambia	3 420	3 250	3 200	4 000
Zimbabwe	100	60	90	n.a.[(a)]
Other market-economy countries	-	-	-	500
	31 380	26 460	21 630	29 100

Source: USBM and others.

(a) Included in 'Other market-economy countries'. (Separate data not available)

TABLE 3.4. WORLD MINE PRODUCTION OF COPPER ('000 t)

	1981	1982	1983	1984(e)
Australia	231	245	261	236
Canada	691	613	653	707
Chile	1 081	1 242	1 257	1 250
Papua New Guinea	165	170	183	164
Peru	328	356	322	370
Philippines	302	293	271	250
Poland	295	376	402	380
South Africa and Namibia	255	256	264	262
USA	1 538	1 140	1 038	1 050
USSR(e)	1 140	1 150	1 180	1 000
Yugoslavia	111	119	130	138
Zaire	505	503	502	525
Zambia	587	530(a)	515(a)	540
Others(e)	1 053	1 152	1 239	1 402
	8 306	8 187	8 189	8 274

Source: WMS, USBM and others.

a) Excludes output from Nchanga lead tailings project.

31

3.3.3 Manganese

World mine production of manganese ore in 1984 is estimated to have been 23.0 Mt. This is equivalent to about 8 Mt of contained manganese (manganese ore typically ranges from 35--54% Mn). The US imported an estimated 373 000 t of manganese ore and 455 000 t of ferromanganese in 1984 (ferromanganese ranges from 74--95% Mn). The output from 3 Mt of dry nodules is 454 000 t/year of ferromanganese (at 78% Mn) (Table 3.2).

Ninety-five percent of manganese ore production goes towards steel production. Demand for manganese is forecast to grow at 1.4%/year, to 10 Mt in the year 2000 (Jones, 1985), in line with steel production. The increase in ferromanganese production is expected to come from countries that have low energy costs and manganese ore deposits such as South Africa and Brazil.

The price of ferromanganese is unlikely to increase in real terms in the immediate future. Recently, ferromanganese producers tried to put up their prices, but there was considerable resistance from buyers, and the profits of ferromanganese producers have suffered as a result (Brown & Murphy, 1985).

The cost of transporting manganese ore from the mine site to port is about 50% of the total production cost (i.e., f.o.b. cost). The cost of ocean shipping adds to the overall cost. In past years, ocean freight has been one-third of the cost of imported ore at eastern ports of the US. This means that manganese production costs are highly dependent on freight costs which over the last few years have been low because of sluggish world trade.

Because of such low rates of growth in manganese consumption and because reserves are about five times as great as the high forecast of 1980--2000 cumulative world demand, excluding ocean nodules (Jones, 1985), the price of manganese or ferromanganese is not expected to increase in real terms.

3.3.4 Nickel

World mine production of nickel in 1983 was 637 100 t (Table 3.5). The output from 3 Mt nodules (dry) would be 36 700 t, approximately 6% of present world production. The demand for nickel is predicted to increase at a rate of 3.1%/year for the world, excluding the US, to 910 000 t in the year 2000, and at 2.5%/year for the US, to 245 000 t in the year 2000 (Sibley, 1985). This compares with the World Bank (1984) which suggests lower growth for the world at 1.1% for period 1979/81 to 1995.

US consumption in 1983 was 185 800 t, of which 138 500 t was imported.

Nickel may be substituted in certain applications. Just now it is being substituted for other metals in alloys owing to the low price. The price is predicted by Telewiak (1985) to increase in real terms in the long term as over-capacity is reduced. In constant 1984 US dollars, the realised price for producers could be close to $3.00/lb by 1990 and remain at the level through the 1990s.

3.4 Metal prices

The prospect of any increase in the real prices of the metal products for a deepsea nodule operation is unlikely according to the current outlook, apart from nickel which may increase in the long term. In Table 3.6, which shows the four metal products prices over the last ten years, there is a definite downward trend when the prices are compared at the second half of 1984 on a dollar value basis. This downward trend is not considered likely to continue but prices will probably not increase appreciably over the next 20--30 years in real terms as technological improvements in exploration, mining and processing of metals throughout the world reduce production costs.

Davies (1983) has emphasised that metal consumption did not rise with industrial production over the seven years to 1981, as it had over the previous 24 years. The impact of this is that demand will be much slower to improve during high growth rates.

TABLE 3.5. WORLD MINE PRODUCTION OF NICKEL ('000 t)

	1980	1981	1982	1983
Albania (e)	8.5	8.8	8.5	9.0
Australia	74.3	74.4	88.6	76.6
Botswana	15.4	18.3	17.8	18.0
Brazil	2.5	2.5	5.3	10.7
Canada	188.5	166.8	92.7	128.1
China. excl. Taiwan Province (e)	11.0	11.0	12.0	12.0
Colombia	-	-	5.0	15.8
Cuba	38.2	40.3	37.6	39.6
Dominican Republic	15.5	17.9	6.0	15.3
Finland	6.4	6.9	6.3	5.3
Greece	14.6	11.8	5.5	8.4
Indonesia	40.6	49.4	48.5	33.3
New Caledonia	86.6	78.2	60.1	42.3
Philippines	38.3	29.2	19.7	17.5

33

South Africa	25.7	25.0	20.5	20.5
USA	13.3	11.0	2.9	-
USSR (e)	143.0	150.0	170.0	170.0
Zimbabwe	14.3	15.1	13.4	8.3
Yugoslavia	0.5	2.0	3.5	3.6
Others (a)	12.1	5.0	5.3	2.8
Total	749.3	723.6	629.2	637.1

Source: WMS and others.

(a) Includes Burma, German Democratic Republic, Guatemala, Morocco, Norway, and Poland; there has been no produciton in Guatemala since 1980.

Considerable time can be spent in determining the most likely price in the future, but it does not change the fact that nobody knows the future price. Therefore, for the base case, the average price for each metal product in March 1985 was used.

3.4.1 Cobalt

The final product of cobalt from the Cuprion process can be more or less complex depending on the requirements of the market (King & Pasho, 1979). It is expected that cobalt powder will be produced, but estimates of prodution cost do not specify the quality of this powder. For this study, it is assumed that it is coarse powder and so the cobalt shot price is used. This price is the same for shot as for cathodes in 250-kg lots. The shot price quoted by Metals Week is the f.o.b. price, Chicago and New York. (The quoted price is based on Afrimet-Indussa prices.) The average shot price for March 1985 was $11.70/lb, i.e., $25 740/t.

3.4.2 Copper

Copper is produced as cathodes in the Cuprion process. The price used in this study is the Metals Week (MW) United States (US) producer/refinery price quoted by Metals Week. This price is an f.o.b. quotation of the MW US producer/delivery price less 1.4 cents/pound shipping cost. The MW US producer/delivery price is a weighted average based on estimated US refined copper production and current cathode selling prices of US producers, quoted on a delivered basis. The average MW US producer/refinery price for March 1985 was ¢64.047/lb, equivalent to $1 410/t.

TABLE 3.6. HALF YEARLY AVERAGES OF COBALT, COPPER, NICKEL AND FERROMANGANESE PRICES -- CURRENT AND ESCALATED WITH US CPI

HALF YEAR		CURRENT PRICES (HALF-YEAR AVERAGES)					ESCALATED PRICES (HALF-YEAR AVERAGES)			
		Co	Cu	Ni	FeMn	CPI	Co	Cu	Ni	FeMn
1	1975	3.97	64.17	2.01	441.7	64.1	7.88	127.40	4.00	877.2
2	1975	4.00	62.97	2.14	413.9	66.6	7.65	120.40	4.09	791.1
1	76	4.17	64.45	2.20	383.0	68.1	7.80	120.50	4.11	716.0
2	76	4.67	71.20	2.27	371.7	70.0	8.49	129.50	4.13	676.0
1	77	5.22	70.01	2.40	340.9	72.5	9.17	122.93	4.21	598.6
2	77	6.00+	61.60	2.14	313.3	74.7	10.23	104.98	3.65	533.9
1	78	7.09	63.27	2.11	310.7	77.4	11.66	104.06	3.46	511.0
2	78	16.14	66.86	2.08	357.0	81.0	25.34	105.08	3.27	561.1
1	79	24.17	89.13	2.41	421.8	85.3	36.07	133.02	3.59	629.5
2	79	25.00	95.18	3.03	458.8	90.9	35.01	133.30	4.24	642.5
1	80	25.00	106.71	3.21	405.0	97.6	32.61	139.18	4.19	528.2
2	80	25.00	98.12	3.45	421.6	102.5	31.05	121.86	4.28	523.6
1	81	21.67	85.50	3.45	407.5	107.8	25.59	100.97	4.07	481.2
2	81	20.00*	81.99	3.41	414.4	112.9	22.55	92.45	3.84	489.4
1	82	12.50*	75.10	3.20	405.6	115.5	13.78	82.77	3.53	447.0
2	82	12.50	70.70	3.20	387.8	118.8	13.39	75.76	3.43	415.5
1	83	12.50	81.48	3.20	328.9	119.6	13.30	86.73	3.41	350.1
2	83	12.50	74.24	3.20	328.3	122.3	13.01	77.28	3.33	341.7
1	84	12.50	73.84	3.20	330.9	124.8	12.75	75.32	3.26	337.5
2	84	12.34	62.55	3.20	333.0	172.3	12.34	62.55	3.20	333.0

Cobalt: shot/cathode price (f.o.b. New York and Chicago) ($/lb)
Copper: Metals Week US producer/refinery price (f.o.b. quotation in Metals Week US producer/delivered price less 1.4¢ shipping cost) (¢/lb)
Nickel: cathode/major producer price (f.o.b. shipping point, US) ($/lb)
Ferromanganese: 78% Mn imported price (f.o.b. Pittsburgh or Chicago warehouse) ($/long ton)

+ List price suspended 28 July 1977 -- 29 November 1977, Metals Week producer price used for this period.
* List price suspended 3 August 1981 -- 1 February 1982.

3.4.3 Ferromanganese

The ferromanganese plant produces ferromanganese with 78% manganese (Mn) content. The price used in this study is the 78% Mn 'imported' ferromanganese price. This price is a US dealer quote, f.o.b. Pittsburgh or Chicago warehouses (Metals Week). The 'imported' price is for alloy, 78% Mn and 7% C (carbon). The price is quoted as a range -- the average is used. The average price for March 1985 was $330/long ton, equivalent to about $325/t.

3.4.4 Nickel

Nickel is produced as cathodes from the Cuprion process, apart from a small quantity of powder, which is washed, dried and briquetted. The cathode/major producer price is used in this study. This price is an f.o.b. quotation from the US shipping point, i.e. producer's site. The nickel price is for cathodes at 99.97% Ni. The average price for March 1985 was ¢3.245/lb, equivalent to $7 155/t.

4. **CASHFLOW ANALYSIS**

Profitability was assessed by calculating the discounted cash flow rate of return (DCFROR). The USBM MINSIM program was used to compute the results. The program has the facility to input point estimates for each variable from which the DCFROR is calculated, or, given a DCFROR, the required metal price is determined. Where the program becomes a very useful tool is in the simulation mode. All prices, costs, etc., can be input in ranges, thereby allowing more realistic estimations of each variable. The output from the simulation is in the form of a distribution of likely DCFRORs with the mean value calculated. The simulation uses the Monte Carlo technique to select values for each year from the input distribution of the cost or price variable. The distribution is not limited to a normal distribution, but allows for the calculation of skewed distributions by fitting a specialised least-squares regression curve. (See Appendix 2; also Thompson, 1983 and Masson, 1983.) The disadvantage of this simulation technique is that all variables are assumed to be independent, whereas this is not true in all cases, e.g., in reality, the grades of copper and nickel are frequently related. However, it is generally true, and so the results are more realistic than the point estimate.

The program allows for the calculation of a discrete DCFROR or a continuous DCFROR. The discrete mode assumes that all expenditure and revenue transactions for a particular year occur at the same time, whereas

36

the continuous mode allows for the spread of these costs over each year using the formula (Thompson, 1983)

$$\text{Net Present Value} = \sum_{n=1}^{L} C_n \cdot \frac{e^r - 1}{re^{rn}} = 0$$

where C = each year's net after-tax cash flow;

L = life of operation in years;

n = sequential number of year being discounted;

r = annual compound interest rate (as a decimal);

e = a constant (2.71828.....);

The results showed that the DCFROR was invariably zero or below. In order that the simulation could be run to show the full range of results above and below zero, the program was amended to allow the calculation of negative DCFRORs. A DCFROR of zero means that expenditure in constant dollar terms equals revenue in constant dollar terms over the life of the operation, or stated another way, the return on expenditure in current dollars equals the rate of inflation. Similarly a negative DCFROR indicates the degree to which the return on expenditure falls short of the inflation rate.

The escalation rates for the metal prices and operating and capital costs were assumed to be the same and so costs and prices were kept in constant-dollar terms throughout (i.e. constant March 1985 US$), so the DCFROR results given are real rates. Where loan repayments or royalty payments were time-dependent, those items were equated to constant-dollar terms by de-escalating the values.

4.1 Base case analysis

Under the Law of the Sea Convention, annex IV, article 13, paragraph 5, The Enterprise will negotiate with host countries for tax-exempt status. Under article 10 of the same annex, The Enterprise is required to make payments to the ISA; however, the details of these payments are not specified. For this study, it was assumed that The Enterprise did not make payments to the ISA or pay taxes. The Enterprise was used as the base case with fully equity.

With a new mining venture, such as mining the ocean floor where there are many unknowns, it was considered that an 18% DCFROR or greater was necessary to encourage investment in such a high-risk venture. Metal price determinations were calculated to give 18% to 26% DCFROR (Table 4.1). It was assumed that the ratio of the revenue from each metal remained as it was in March 1985.

37

4.2 Cost distribution

The base case in this study used point estimates of the most likely costs. As mentioned, the disadvantage of this is the low levels of confidence involved. For this reason a range or distribution of each input variable was compiled.

The ranges of the input variables is given in Table 4.2, and information on the determination of their distributions in Appendix 3.

4.3 Price distribution

For the simulation, price ranges were used, based on present market trends and historical trends and also on advice from the mineral commodity specialists at BMR. It was considered that the most probable price would be the current (March 1985) price, except for nickel where a 10% increase was considered to be most probable.

TABLE 4.1. PRICE DETERMINATION FOR THE ENTERPRISE (WITH FULL EQUITY) BASE CASE WITH GIVEN DCFRORs

DCFROR	Revenue required per tonne of dry nodules ($/t)	Cobalt $/t ($/lb)	Copper $/t ($/lb)	Nickel $/t ($/lb)	Ferro-manganese $/t ($/long ton)
18	366	48 950(22.25)	2670(1.21)	13 540(6.15)	610(620)
20	405	54 150(24.61)	2950(1.34)	14 980(6.81)	680(690)
22	450	60 240(27.38)	3280(1.49)	16 660(7.57)	750(770)
24	504	67 370(30.62)	3670(1.67)	18 630(8.47)	840(860)
26	566	75 750(34.43)	4130(1.88)	20 950(9.52)	950(965)
March 1985 prices		25 740(11.70)	1410(0.64)	7 155(3.25)	325(330)

38

TABLE 4.2. DISTRIBUTIONS OF INPUT VARIABLES

	Range		Distribution type
	Low limit (-%)	High limit (+%)	
1. Capital			
a. Exploration	-10	+ 50	Skewed (positive)
b. Research & development	-10	+ 60	Skewed (positive)
c. Mining capital	-10	+100	Skewed (positive)
d. Transport capital	-15	+ 15	Normal
e. Slurry terminal	-30	+ 50	Skewed (positive)
f. Slurry pipeline	-40	+ 60	Skewed (positive)
g. Process plant	-10	+ 60	Skewed (positive)
2. Operating			
a. Mine ships	-20	+ 60	Skewed (positive)
b. Transport ships	-20	+ 30	Skewed (positive)
c. Processing	-10	+ 30	Skewed (positive)
d. Transport to market	-50	+ 50	Normal
3. Grade			
a. Cobalt	-10	+ 10	Normal
b. Copper	-10	+ 10	Normal
c. Manganese	-10	+ 10	Normal
d. Nickel	-10	+ 10	Normal
4. Recovery			
a. Cobalt	- 8	+ 8	Normal
b. Copper	- 2	+ 2	Normal
c. Manganese	- 9	+ 9	Normal
d. Nickel	- 2	+ 2	Normal

Note: the determination of these input variables is given in Appendix 3.

4.3.1 Cobalt	probability	price, \$/t (\$/lb)
	0.05	14 200 (6.45)
	0.20	20 000 (9.08)
	0.40	25 740 (11.70)
	0.30	31 500 (14.33)
	0.05	37 300 (16.95)

The cobalt price is expected to remain stable at the current level or within ± 25%. There is a low probability that it might fluctuate within 39

± 50%. If there is any change an increase is considered more likely than a decrease.

4.3.2 Copper

probability	price, \$/t (¢/lb)
0.10	1270 (58)
0.20	1410 (64)
0.16	1550 (70)
0.14	1690 (77)
0.12	1830 (83)
0.10	1970 (90)
0.08	2110 (96)
0.06	2250 (102)
0.04	2390 (109)
0.02	2530 (115)

The price of copper is expected to range between \$1267/t and \$2534/t, with a definite upward tendency from the present price of \$1410/t. Within the last five years the price has varied upwards to this limit. However, new trend lines in copper price are possibly being formed. As the present price is extremely low, the range of prices is taken as -14% to +90%.

4.3.3 Ferromanganese

probability	price, \$/t
0.05	250
0.30	320
0.30	380
0.20	450
0.10	510
0.05	570

The present price of ferromanganese (78% Mn content) is also particularly low. For this reason the most probable price is expected to be between the present price and a 20% rise. The full range is taken as -20% and +80%.

4.3.4 Nickel

probability	price, \$/t
0.10	5710 (2.60)
0.15	6425 (2.90)
0.20	7140 (3.25)
0.25	7850 (3.60)
0.20	8570 (3.90)
0.10	9280 (4.20)

The price range for nickel is expected to be from -20% to +30%. There is a high probability that the price will go up in line with the relatively good prospects for nickel detailed in the Revenue Section 3.3.4. 40

4.4 Base case simulation

As shown in Table 4.3, as the metal prices are weighted upwards they outweigh the costs which are similarly weighted to give a mean DCFROR of 1.88%, which is 1.81% higher than the point estimate of the base case. The range of the DCFRORs is only 6%, with the maximum DCFROR well below the 18% threshold required to make the venture viable.

TABLE 4.3. SIMULATION RESULTS FOR THE ENTERPRISE (WITH FULL EQUITY)(BASE CASE)

RATE OF RETURN (%)	FREQUENCY DISTRIBUTION (%)	
-1	2.7	***
0	5.3	*****
1	26.0	**************************
2	38.7	***************************************
3	25.3	*************************
4	2.0	**

Mean rate of return, 1.88%.

4.5 Enterprise finance

The financial arrangements of The Enterprise, as set out in the Law of the Sea Convention, annex IV, article 11, are that half the equity will be provided by State Parties in the form of an interest-free loan. The other half will be obtained through commercial loans guaranteed by the State Parties. It is assumed for this study that the commercial loan will attract a 10% interest rate and would be paid back over the twenty years of full production.

It is assumed that the bank loan would be repayed in equal instalments over the twenty years, and thus the real value of the repayments will drop each year because of escalation. The escalation rate is assumed to be 7.3% See Appendix 4 for details of the bank loan repayments.

After the first venture, the Law of the Sea Convention requires The Enterprise to be self-supporting, with no capital input from any member state or guarantees for bank loans. If The Enterprise is to have enough capital in reserve to start a second mining venture, then it will be required to achieve a DCFROR that will produce full equity plus the loan repayment on the first venture.

The simulation result of the DCFROR for this case with full equity and loan repayment is given in Table 4.4. The result is a mean rate of return of -2.56% which is a drop of over 4% from the base case. No results had positive DCFRORs, which indicates expenditure was higher than revenue in all cases.

If The Enterprise is to commence the second operation with half equity, then the DCFROR is calculated on half equity for the first venture and half of the loan repayment. As shown in Table 4.5, the mean rate of return for this scenario is 1.00% and the range is from -3% to +4%.

TABLE 4.4. SIMULATION RESULTS FOR THE ENTERPRISE WITH FULL EQUITY AND LOAN REPAYMENTS FOR EQUITY BORROWED (i.e. ALLOWANCE MADE FOR STARTING SECOND VENTURE WITH FULL EQUITY)

Rate of return (%)	Frequency distribution (%)	
-7	0.7	*
-6	1.3	*
-5	6.0	******
-4	14.0	**************
-3	26.0	**************************
-2	29.3	*****************************
-1	20.0	********************
0	2.7	***

Mean rate of return, -2.56%.

TABLE 4.5. SIMULATION RESULTS FOR THE ENTERPRISE WITH HALF EQUITY AND LOAN REPAYMENTS FOR HALF OF EQUITY BORROWED

Rate of return (%)	Frequency distribution (%)	
-3	0.7	*
-2	1.3	*
-1	12.0	************
0	23.3	***********************
1	25.3	*************************

42

2	23.3	***********************
3	10.7	***********
4	3.3	***

Mean rate of return, 1.00%.

4.6 Australian company

The DCFROR calculations for the Australian company are based on full equity financing.

Under annex III, article 13 of the Law of the Sea Convention, any contractor mining the ocean floor is required to make certain payments to the International Sea-bed Authority. The charges can be divided into three.

a) An application fee of US$500 000 is required to be paid when applying for approval of a plan of work within a non-reserved area.

b) Upon approval of a plan of work, an annual fixed fee of US$1 million is required to be paid until production starts.

c) Production charge. When production commences, there is a choice of two charges to be paid by the contractor. One is based solely on a percentage of the value of the processed metal produced. The other is based partly on a percentage of the value of the processed metal produced and partly on a percentage of the attributable net proceeds of the contractor; the percentage rate being dependent on the rate of return on investment.

In calculating the payments required for the Australian company, the straight percentage of the value of the processed metal produced was chosen. The annual rate for the first ten years of production is 5% and from year eleven onwards it is 12%. The pre-production charge of US$1 million/year is payable each year in dollars of the day. The US$1 million charge was deflated for each year of payment to the first year of production at a rate 7.3% (the average annual rate of the US CPI over the last ten years). A summary of the payments is given below, based on a pre-production period of 11 years.

Year	Payment
1	$ 500 000
2	$1 000 000
3	$ 932 000
4	$ 868 600
5	$ 809 500

6	$ 754 400
7	$ 703 100
8	$ 655 200
9	$ 611 000
10	$ 569 000
11	$ 530 000
12--21	5% of metal value
22--34	12% of metal value

The production charge of 5% and 12% of metal value is $29.0 million/year and $69.7 million/year respectively at March 1985 metal prices. If the metal prices rose to the level mentioned in the previous section to achieve an 18% p.a. DCFROR (Table 4.1), the production charge would be $54.9 million/year (5%) and $131.8 million/year (12%).

The Australian company which would be required to make payments to the ISA, is estimated to have a mean DCFROR of 0.02% before tax. This is a drop of 1.86% from The Enterprise (base case). The range of the DCFRORs is +2% to -4%. The distribution from the simulation is given in Table 4.6.

TABLE 4.6. SIMULATION RESULTS FOR AN AUSTRALIAN COMPANY USING THE CUPRION PROCESS, BEFORE TAX

Rate of return (%)	Frequency distribution (%)	
-4	0.7	*
-3	2.0	**
-2	6.0	******
-1	21.3	*********************
0	34.7	***********************************
1	26.7	***************************
2	8.7	*********

Mean rate of return, 0.02%.

4.7 Taxation

An Australian company would be required to pay Australian income tax. The rate of the present Australian corporate income tax for companies is 46% of gross revenue less operating costs and depreciation. This would reduce the DCFROR from 0.02% to -1.19% and the maximum of the range would drop from +2% to 1%. As the company would not be making any profit, the difference between 'before tax' and 'after tax' is only slight. If the venture were to become profitable, the difference between before and after tax DCFROR would become more significant.

An established Australian company could use the losses in this venture to reduce its overall tax liability. However, in this study the feasibility for the Australian company of undertaking this venture was considered in isolation from its existing activities.

4.8 Alternative processes

Several nodule-processing methods are available (Table 2.1). The base case in this study is based on the Cuprion process as detailed by Hillman (1983), but the reduction ammonia leach (RAL) process and the pyrometallurgical process were also considered for comparison. The RAL process is similar to the Cuprion process but there are significant differences in metal recovery and cost. Costs of these two processes were taken from Little (1984) and escalated to March 1985 dollars. Little (1984) gives total capital costs and total operating costs with no breakdown, so there may be some over- and under- estimations in the component cost areas.

TABLE 4.7. SIMULATION RESULTS FOR AN AUSTRALIAN COMPANY USING THE CUPRION PROCESS, AFTER TAX

Rate of return (%)	Frequency distribution (%)	
-5	2.7	***
-3	10.7	***********
-2	23.3	***********************
-1	31.3	*******************************
0	29.3	*****************************
1	2.7	***

Mean rate of return, -1.19%.

4.8.1 Pyrometallurgical process

Little's (1984) estimate of the capital cost is $1112 million (1st quarter 1984 US$). This was escalated for skilled labour (30%), steel (25%), construction materials (25%) and equipment (20%) indexes, to give a total cost of $1134 million. The construction period of six years for a Cuprion process plant was assumed to be the same for a pyrometallurgical process plant.

The estimate by Little (1984) for the operating cost of the pyrometallurgical process is $541 million/year (1st quarter 1984 US$). This was escalated for fuel and power (60%), industrial materials (20%) and unskilled labour (30%) indexes to give an annual cost of $548 million. The operating cost of the port is $10.2 million, which gives a total operating cost of $558.2 million. This gives $186.1/t of nodules (dry) per year processed. The handling facilities for the nodules for the Cuprion process will not be suitable for the pyrometallurgical process, so costs may be higher for handling, but they are assumed for this study to be the same.

The recovery factors for the four metal products from the pyrometallurgical process are given in Table 4.8.

The effect on the profitability of both The Enterprise and Australian company is negative using this process, as shown in Tables 4.9 and 4.10, but this process is proven and may be more attractive to an operator than the Cuprion. The mean DCFROR for The Enterprise drops from 1.88% for the Cuprion process to -2.90% for this process, and for the Australian company, it drops from 0.02% to -13.67%. Both are skewed to the negative side, with very low minima.

TABLE 4.8. PYROMETALLURGICAL PROCESS PRODUCT RECOVERY FACTORS

Metal	Recovery factor (%)
Cobalt	70%
Copper	90%
Manganese (ferromanganese)	85%
Nickel	90%

TABLE 4.9. SIMULATION RESULTS FOR THE ENTERPRISE (WITH FULL EQUITY) USING THE PYROMETALLURGICAL PROCESS

Rate of return (%)	Frequency distribution (%)	
-9	0.7	*
-8	0.7	*
-7	3.3	***
-6	4.0	****
-5	8.7	*********
-4	10.7	***********
-3	24.7	*************************
-2	26.7	***************************
-1	16.7	*****************
0	4.0	****

Mean rate of return, -2.90%.

TABLE 4.10. SIMULATION RESULTS FOR AN AUSTRALIAN COMPANY (BEFORE TAX) USING PYROMETALLURGICAL PROCESS

Rate of return (%)	Frequency distribution (%)	
-40	0.4	
-34	0.4	
-33	0.8	*
-32	0.8	*
-31	0.4	
-30	0.4	
-29	0.4	
-28	0.4	
-27	0.8	*
-26	2.0	**
-25	0.8	*
-24	0.8	*
-23	1.2	*
-22	1.6	**

47

-21	0.8	*
-20	2.0	**
-19	2.0	**
-18	3.2	***
-17	3.6	****
-16	3.2	***
-15	5.6	******
-14	6.0	******
-13	10.0	**********
-12	8.8	*********
-11	9.6	**********
-10	9.2	*********
-9	9.6	**********
-8	8.0	********
-7	4.0	****
-6	2.8	***
-4	0.4	

Mean rate of return, -13.67%.

4.8.2 <u>Reduction ammonia leach (RAL) process</u>

Little's (1984) estimate for the capital cost of this process is $1112 million (1st quarter 1984 US$). This cost was escalated with the same index ratios as for the pyrometallurgical process, and gave a March 1985 capital cost of $1134 million. A construction period of six years was again assumed.

Little's (1984) estimate of the annual operating cost was $483 million for 3Mt of dry nodules. This was escalated for unskilled labour (30%), industrial materials (30%), fuel (25%), skilled labour (15%) indexes to give $491.7 million. Added to this cost is the operation of the port, which gives a combined cost of $501.9 million, or $167.3/t.

The recovery factors for the four metal products from the RAL process are given in Table 4.11.

As with the pyrometallurgical process, no improvement in profitability is found with the estimated costs, as shown in Tables 4.12 and 4.13. The mean DCFROR for The Enterprise drops from 1.88% to 0.43%, and for the Australian company from 0.02% to -4.71%.

The Cuprion process is not very different from the RAL process and profitability is similar for The Enterprise. With the present uncertainty on costs, the difference between the two is regarded as insignificant. The higher recovery of manganese for the pyrometallurgical process can only put it ahead of the other processes given a high price for ferromanganese.

TABLE 4.11. REDUCTION AMMONIA LEACH PROCESS PRODUCT RECOVERY FACTORS

Metal	Recovery factor (%)
Cobalt	65
Copper	90
Manganese (ferromanganese)	85
Nickel	90

TABLE 4.12. SIMULATION RESULTS FOR THE ENTERPRISE (WITH FULL EQUITY) USING THE REDUCTION AMMONIA LEACH PROCESS

Rate of return (%)	Frequency distribution (%)	
-3	0.7	*
-2	6.0	******
-1	12.0	************
0	26.0	**************************
1	38.7	**************************************
2	16.2	****************
3	0.7	*

Mean rate of return, 0.43%.

TABLE 4.13. SIMULATION RESULTS FOR AN AUSTRALIAN COMPANY (BEFORE TAX) USING THE REDUCTION AMMONIA LEACH PROCESS

Rate of return (%)	Frequency distribution (%)	
-13	0.7	*
-11	2.0	**
-10	2.0	**
-9	3.3	***
-8	3.3	***
-7	6.7	*******
-6	7.3	*******
-5	18.0	******************
-4	28.0	****************************
-3	14.0	**************
-2	12.7	*************
-1	2.0	**

Mean rate of return, -4.71%.

5. CONCLUSIONS

1. At the present metal prices, the mining of polymetallic nodules for cobalt, copper, nickel and manganese from the deep-seabed is not a viable proposition, either for an Australian company or for The Enterprise; increases in aggregate metal prices, to as high as twice their present level, would be required to make the mining venture viable.

2. Even if the metal prices rise significantly for a 3Mt/year operation, the volume of output of cobalt especially, and also of ferromanganese and nickel, would have a significant effect on the market. The metal prices would probably go down and it would be doubtful whether all output could be sold at market price.

3. The technology of mining nodules from the deep sea-bed has not yet been proved. For this reason, the venture must be considered high-risk and therefore a high discounted cash flow rate of return would be necessary, in order to attract capital. 50

4. With the present metal price levels and ratios between the prices, the Cuprion process is more attractive than pyrometallurgical process and the reduction ammonia leach process.

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APPENDIX 1 - Cost indexes (US)

The table details the indexes used in escalating the cost estimates. The Indexes were obtained from the US Bureau of Mines (USBM) except for the US CPI which was obtained from International Financial Statistics (IFS), produced by the IMF. The USBM indexes are based on Employment and Earnings and Wholesale Prices and Price Indexes, published by Bureau of Labor Statistics (BLS) of the US Department of Labor, and on Engineering News Record (ENR). The source of each index is detailed below each column.

APPENDIX 2 - Probability methodology (for cashflow analysis)

Randomisation is accomplished for the evaluator as follows:

a) Each normally distributed random value is obtained by subtracting six from the sum of twelve uniformly distributed random numbers whose range is the open interval (0,1); this value is then multiplied by the standard deviation, which is assumed to be one-sixth of the high and low values, and is added to the mean.

b) For non-normal distributions, a specialised least-squares regression subroutine is used to fit a curve, in the form y = F(x), to the cumulative probability defined by the four or more points. Random (y) values in the open interval (0,1) are distributed by solving the 53
resultant equation [i.e., y = F(x)].

TABLE (Appendix 1). US COST INDEXES (for explanation of sources see text)

Year	Mining labor	Constrn labor	Equip. & parts	Bits & steel	Timber & lumber	Fuel	Tyres	Constrn materl	Industrl materl	Transport	CPI
BASE	5.89	1996.70	184.90	197.30	196.80	258.80	158.80	185.00	171.20	185.70	100.00
1970AVG	3.85	1318.00	115.90	115.10	113.70	101.00	105.40	124.40	110.00	108.90	-
1971AVG	4.06	1487.00	121.40	121.80	135.50	106.80	110.30	141.07	114.00	123.50	-
1972AVG	4.41	1621.00	125.70	128.40	159.40	108.90	111.30	154.63	117.90	128.10	-
1973AVG	4.73	1725.00	130.70	136.20	205.20	128.70	115.70	168.42	125.90	133.00	-
1974AVG	4.73	1836.00	152.30	178.60	207.10	223.40	141.60	178.30	153.80	155.00	-
1975AVG	5.90	1983.00	185.20	200.90	192.50	257.50	155.40	193.27	171.50	178.40	65.30
1976AVG	6.46	2133.00	198.60	215.80	233.00	276.40	172.80	201.94	182.30	197.80	69.10
1977AVG	6.94	2264.00	213.70	230.30	276.50	308.10	181.50	228.61	195.10	211.10	73.60
1978AVG	7.67	2405.00	232.80	253.50	322.10	321.00	192.00	247.70	209.40	227.30	79.20
1979AVG	8.48	2564.00	255.60	283.40	354.20	444.50	219.40	266.10	236.20	264.40	88.10
1980AVG	9.19	2767.00	288.90	305.00	325.60	674.30	249.70	287.70	274.20	311.30	100.00
1981AVG	10.06	3025.00	320.80	333.80	325.10	805.90	270.20	310.33	304.10	355.30	110.40
1982AVG	10.82	3345.00	343.90	339.00	310.90	761.20	271.60	330.10	312.30	387.30	117.10
1983AVG	11.27	3587.00	351.90	343.30	352.60	684.30	260.00	352.89	315.70	395.40	120.90
1984AVG	11.57	3734.00	357.90	358.40	100.00	662.90	258.30	358.76	322.10	411.00	126.10
1985JAN	11.77	3759.00	360.40	357.40	343.20	636.20	262.00	358.32	323.20	413.60	128.10
1985FEB	11.85	3763.00	361.70	357.70	342.90	615.90	247.70	359.04	322.50	413.60	128.60
1985MAR	11.82	3765.00	361.80	358.20	345.00	620.70	247.00	359.38	322.60	413.60	129.20
SOURCE	BLS	ENR	BLS	BLS	BLS	BLS	BLS	ENR	BLS	BLS	IFS

APPENDIX 3 - Determination of distributions of input variables (Table 4.2)

1. Capital

Items a, b and g (Exploration, Research & development, Process plant)

The distribution of costs of these items reflects the low uncertainty, as much work has already been carried out in these areas. The positive skewness of the distribution reflects the anticipated over-expenditure due to uncertainties, such as construction delays.

Item c (Mine ships)

The estimate of the total cost of these two ships in this study is low compared to other estimates mainly because of the use of Japanese-built as opposed to USA-built ships. As the estimate is low compared to other estimates it is felt that the confidence of this low figure is also low. As a consequence the distribution of costs for this item is high on the upward side.

Items d, e and f (Transport, Slurry terminal, Slurry pipeline)

The distributions of these three items is based on Andrews & others (1983).

2. Operating

Items a and c (Mine ships, Processing)

These items were assumed to be skewed positively, and the operating costs are likely to be higher operating costs than estimated rather than lower. The operation of the mining system still has to be proved at this stage and so the highest uncertainty is placed on this cost.

Item c (Transport ships)

This distribution reflects the estimates of Andrews & others (1983) which show a distribution of -13% to +24%.

Item d (Transport to market)

The location of the market affects the transport cost. The cost thus may vary considerably and so a low level of confidence is placed on it.

55

3. Grade

The distributions for grade have been assumed to be 10%. If the grade varies more than this, it is assumed that the mine ship will move to an area where grade is expected to be more consistent.

4. Recovery

Copper and nickel recoveries are unlikely to fluctuate very much with the Cuprion process. Cobalt recovery has been quoted as 65% (Hillman, 1983) and 50% (Pasho, 1979) and so a range from 50% to 70% was used. It is assumed that the final manganese recovery may vary with the various hydro- and pyro-metallurgical processes it goes through. Therefore the distribution for manganese recovery is set higher than the other three metals.

APPENDIX 4 - Loan repayments for The Enterprise

(Total loan at year 14* is US$1111.3 million, rate of interest 10%, escalation rate 7.3%)

Year	Interest payments	Interest payments de-escalated	Repayment of principal	Repayment of principal de-escalated
14	111.1	111.1	19.4	19.4
15	109.2	101.8	21.3	19.9
16	107.1	93.0	23.7	20.6
17	104.7	84.8	25.8	20.9
18	102.1	77.1	28.4	21.4
19	99.3	69.8	31.2	22.0
20	96.2	63.0	34.4	22.5
21	92.7	56.6	37.8	23.1
22	89.0	50.6	41.6	23.7
23	84.8	45.0	45.7	24.3
24	80.2	39.6	50.3	24.9
25	75.2	34.6	55.4	25.5
26	69.7	29.9	60.9	26.1
27	63.6	25.4	67.0	26.8
28	56.9	21.2	73.7	27.5
29	49.5	17.2	81.0	28.2
30	41.4	13.4	89.1	28.9
31	32.5	9.8	98.1	29.6
32	22.7	6.4	107.9	30.3
33	12.0	3.1	118.8	31.1

* The loan repayments commence on the first year of full production.

Supplement to Economic Viability of Deep-Sea Bed Mining of Polymetallic Nodules

25

15

Contents

Description of Computer Output

The first output details the income and expenditure for the Enterprise over 34 years. The bulk of the output is detailed costs with a summary page at the end.

The point estimates of costs used in the base case are the modes of the distributions used in base case simulation. The ranges of the distributions are given in the main text.

The second output initially gives details of the cost and price distributions that are used for each input. The detailed income and expenditure is for one only of the 150 simulations. The last two pages give a summary of the simulations with a histogram of the DCFROR.

BUREAU OF MINERAL RESOURCES OF AUSTRALIA

FINANCIAL EVALUATION

ENTERPRISE EVALUATION -3MILLION TONNES NODULES(DRY) P.A. [CUPRION PROCESS]

BEGINNING OPERATION IN 1
AND ENDING OPERATION IN 34
WITH 11 PREPRODUCTION YEARS
USING 1 SIMULATION(S) AND
A TARGET RATE OF RETURN OF
18.0 PERCENT
CONTINUOUS DISCOUNTED CASHFLOW IS USED

TAX PARAMETER LIST BY INPUT RECORD

```
COMMODITY RECORD FOR COBALT
     SEVERANCE TAX OPTION = NO SEVERANCE TAX
     FIXED SEVERANCE AMOUNT ($1000) =      0.0
     DEPLETION ALLOWANCE OPTION = NO DEPLETION
     DEPLETION ALLOWANCE =  0.0
     FIXED DEPLETION AMOUNT ($1000) =     0.0
     PAID-FOR PERCENTAGE =      1.000

COMMODITY RECORD FOR COPPER
     SEVERANCE TAX OPTION = NO SEVERANCE TAX
     FIXED SEVERANCE AMOUNT ($1000) =      0.0
     DEPLETION ALLOWANCE OPTION = NO DEPLETION
     DEPLETION ALLOWANCE =  0.0
     FIXED DEPLETION AMOUNT ($1000) =     0.0
     PAID-FOR PERCENTAGE =      1.000

COMMODITY RECORD FOR NICKEL
     SEVERANCE TAX OPTION = NO SEVERANCE TAX
     FIXED SEVERANCE AMOUNT ($1000) =      0.0
     DEPLETION ALLOWANCE OPTION = NO DEPLETION
     DEPLETION ALLOWANCE =  0.0
     FIXED DEPLETION AMOUNT ($1000) =     0.0
     PAID-FOR PERCENTAGE =      1.000

COMMODITY RECORD FOR MANGANESE
     SEVERANCE TAX OPTION = NO SEVERANCE TAX
     FIXED SEVERANCE AMOUNT ($1000) =      0.0
     DEPLETION ALLOWANCE OPTION = NO DEPLETION
     DEPLETION ALLOWANCE =  0.0
     FIXED DEPLETION AMOUNT ($1000) =     0.0
     PAID-FOR PERCENTAGE =      1.000
RATE OF RETURN IS LESS THAN MINUS 90 PCT IN YEAR   13
RATE OF RETURN IS LESS THAN MINUS 90 PCT IN YEAR   14
```

	1	2	3	4	5	6	7	8	9
GENERAL DATA * * * * * * * * *									
INVESTMENTS									
EXPLORATION - - - - - - - - -	3500000.	3500000.	3500000.	3500000.	3500000.	3500000.	0.	0.	0.
LAND ACQUISITION- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
RESEACH & DEVELOPMENT,- - -	16800000.	16800000.	16800000.	16800000.	16800000.	42000000.	42000000.	0.	0.
INVEST. NUMBER 1- MINE- - -	0.	0.	0.	0.	0.	0.	47900000.	47900000.	47900000.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	10	10	10
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 2- TRAN- - -	0.	0.	0.	0.	0.	0.	14000000.	14000000.	14000000.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	10	10	10
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 4- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	22100000.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	0	0	10
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 5- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 6- PROC- - -	0.	0.	0.	0.	0.	0.	132400000.	132400000.	132400000.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	10	10	10
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUITY CAPITAL- - - - - - -	20300000.	20300000.	20300000.	20300000.	20300000.	45500000.	236300000.	194300000.	216400000.
WORKING CAPITAL - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPERATING COSTS PER UNIT									
MINE- - - - - - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRANSPORT - - - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PROCESS - - - - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNITS TREATED- - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
MISC. OPERATING EXPENSES - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COMMODITY DATA * * * * * * * *									
COBALT									
ORE GRADE - - - - - - - - -	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600
MILL RECOVERY - - - - - - -	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00
UNITS RECOVERED - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
REVENUES- - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER									
ORE GRADE - - - - - - - - - -	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400
MILL RECOVERY - - - - - - - -	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRICE/UNIT RECOVERED- - - -	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00
UNITS RECOVERED - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
REVENUES- - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
NICKEL									
ORE GRADE - - - - - - - - - -	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300
MILL RECOVERY - - - - - - - -	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00
UNITS RECOVERED - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
REVENUES- - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
MANGANESE									
ORE GRADE - - - - - - - - - -	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000
MILL RECOVERY - - - - - - - -	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00
UNITS RECOVERED - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
REVENUES- - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
FINANCIAL SUMMARY * * * * * *									
CASH FLOW									
EXPENSED EXPLORATION +									
TOTAL REVENUES- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS MINE OPERATING COSTS -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS TRAN OPERATING COSTS -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS PROCESS OPERATING COSTS	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS TRANS TO MARKET- - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS EXPLORATION COSTS- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEVELOPMENT COSTS- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS LOAN INT. PAYMENTS - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEPRECIATION - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS TOTAL ROYALTY PAYMENTS-	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUALS NET INCOME - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLUS DEPRECIATION - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLUS TOTAL DEPLETION USED -	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLUS DEFFERED DEDUCTIONS- -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS EQUITY INVESTMENT- - -	20300000.	20300000.	20300000.	20300000.	20300000.	45500000.	236300000.	194300000.	216400000.
EQUALS CASH FLOW- - - - - -	-20300000.	-20300000.	-20300000.	-20300000.	-20300000.	-45500000.	-236300000.	-194300000.	-216400000.
ANALYSIS FIGURES									
CONTINUOUS RATE OF RETURN -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NOTE - * INDICATES THAT A DUAL RATE OF RETURN EXISTED IN THAT YEAR									
18.00 PCT PRESENT VALUE- -	-18577824.	-34095312.	-47056608.	-57882800.	-66925584.	-83855120.	-157293760.	-207732064.	-254653552.

	10	11	12	13	14	15	16	17	18
GENERAL DATA * * * * * * * * *									
INVESTMENTS									
EXPLORATION - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAND ACQUISITION- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
RESEACH & DEVELOPMENT,- - -	0.	3200000.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 1- MINE- - -	47900000.	47900000.	72700000.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	10	10	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	12060000.	16850000.	21640000.	26430000.	31220000.	31220000.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 2- TRAN- - -	14000000.	14800000.	14800000.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	10	10	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	2880000.	5760000.	7160000.	8560000.	8560000.	8560000.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 4- PROC- - -	22100000.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	2210000.	4420000.	4420000.	4420000.	4420000.	4420000.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 5- PROC- - -	11050000.	11050000.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	10	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	1105000.	2210000.	2210000.	2210000.	2210000.	2210000.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 6- PROC- - -	132400000.	132400000.	132400000.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	10	10	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	13240000.	26480000.	39720000.	52960000.	66200000.	79440000.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUITY CAPITAL- - - - - - -	227450000.	209350000.	554499584.	0.	0.	0.	0.	0.	0.
WORKING CAPITAL - - - - - -	0.	0.	334599936.	0.	0.	0.	0.	0.	0.
OPERATING COSTS PER UNIT									
MINE- - - - - - - - - - - -	0.0	0.0	31.00000	31.00000	31.00000	31.00000	31.00000	31.00000	31.00000
TRANSPORT - - - - - - - - -	0.0	0.0	8.83000	8.83000	8.83000	8.83000	8.83000	8.83000	8.83000
PROCESS - - - - - - - - - -	0.0	0.0	123.53000	123.53000	123.53000	123.53000	123.53000	123.53000	123.53000
UNITS TREATED- - - - - - - -	0.	0.	1500000.	2500000.	3000000.	3000000.	3000000.	3000000.	3000000.
MISC. OPERATING EXPENSES - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COMMODITY DATA * * * * * * * *									
COBALT									
ORE GRADE - - - - - - - - -	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600
MILL RECOVERY - - - - - - -	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00
UNITS RECOVERED - - - - - -	0.	0.	2535.	4225.	5070.	5070.	5070.	5070.	5070.
REVENUES- - - - - - - - - -	0.	0.	65250880.	108751392.	130501696.	130501696.	130501696.	130501696.	130501696.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER									
ORE GRADE - - - - - - - - - -	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400
MILL RECOVERY - - - - - - - -	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRICE/UNIT RECOVERED- - - -	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00
UNITS RECOVERED - - - - - -	0.	0.	14352.	23920.	28704.	28704.	28704.	28704.	28704.
REVENUES- - - - - - - - - -	0.	0.	20236320.	33727200.	40472640.	40472640.	40472640.	40472640.	40472640.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
NICKEL									
ORE GRADE - - - - - - - - - -	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300
MILL RECOVERY - - - - - - - -	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00
UNITS RECOVERED - - - - - -	0.	0.	18354.	30590.	36708.	36708.	36708.	36708.	36708.
REVENUES- - - - - - - - - -	0.	0.	131322864.	218871472.	262645760.	262645760.	262645760.	262645760.	262645760.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
MANGANESE									
ORE GRADE - - - - - - - - - -	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000
MILL RECOVERY - - - - - - - -	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00
UNITS RECOVERED - - - - - -	0.	0.	176880.	294800.	353760.	353760.	353760.	353760.	353760.
REVENUES- - - - - - - - - -	0.	0.	73405168.	122341968.	146810368.	146810368.	146810368.	146810368.	146810368.

DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

FINANCIAL SUMMARY * * * * * *

CASH FLOW									
EXPENSED EXPLORATION + TOTAL REVENUES- - - - - - - -	0.	0.	290215168.	483691776.	580430336.	580430336.	580430336.	580430336.	580430336.
LESS MINE OPERATING COSTS -	0.	0.	46500000.	77500000.	93000000.	93000000.	93000000.	93000000.	93000000.
LESS TRAN OPERATING COSTS -	0.	0.	13244999.	22074992.	26489984.	26489984.	26489984.	26489984.	26489984.
LESS PROCESS OPERATING COSTS	0.	0.	185294992.	308824832.	370589952.	370589952.	370589952.	370589952.	370589952.
LESS TRANS TO MARKET- - - -	0.	0.	9097370.	15162286.	18194736.	18194736.	18194736.	18194736.	18194736.
LESS EXPLORATION COSTS- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEVELOPMENT COSTS- - -	0.	0.	3920610.	6534350.	7841220.	7841220.	7841220.	7841220.	7841220.
LESS LOAN INT. PAYMENTS - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEPRECIATION - - - - - -	0.	0.	0.	31494992.	55720000.	75150000.	94580000.	112610000.	125850000.
LESS TOTAL ROYALTY PAYMENTS-	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUALS NET INCOME - - - - - -	0.	0.	32157216.	22100736.	8594944.	-10834944.	-30265088.	-48294912.	-61534976.
PLUS DEPRECIATION - - - - - -	0.	0.	0.	31494992.	55720000.	75150000.	94580000.	112610000.	125850000.
PLUS TOTAL DEPLETION USED -	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLUS DEFFERED DEDUCTIONS- -	0.	0.	3920610.	6534350.	7841220.	7841220.	7841220.	7841220.	7841220.
LESS EQUITY INVESTMENT- - -	227450000.	209350000.	554499584.	0.	0.	0.	0.	0.	0.
EQUALS CASH FLOW- - - - - - -	-227450000.	-209350000.	-518421504.	60130064.	72156160.	72156272.	72156128.	72156304.	72156240.

ANALYSIS FIGURES									
CONTINUOUS RATE OF RETURN -	0.0	0.0	0.0	-90.000	-90.000	-40.000	-40.000	-31.242	-24.391

NOTE - * INDICATES THAT A DUAL RATE OF RETURN EXISTED IN THAT YEAR

18.00 PCT PRESENT VALUE- -	-295846912.	-327516416.	-393021952.	-386675712.	-380314624.	-375001344.	-370563328.	-366856448.	-363760128.

	19	20	21	22	23	24	25	26	27
GENERAL DATA * * * * * * * * *									
INVESTMENTS									
EXPLORATION - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAND ACQUISITION- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
RESEACH & DEVELOPMENT,- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 1- MINE- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	31220000.	31220000.	31220000.	31220000.	19160000.	14370000.	9580000.	4790000.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 2- TRAN- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	8560000.	8560000.	8560000.	8560000.	5680000.	2800000.	1400000.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 4- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	4420000.	4420000.	4420000.	4420000.	2210000.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 5- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	2210000.	2210000.	2210000.	2210000.	1105000.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 6- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	79440000.	79440000.	79440000.	79440000.	66200000.	52960000.	39720000.	26480000.	13240000.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUITY CAPITAL- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
WORKING CAPITAL - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPERATING COSTS PER UNIT									
MINE- - - - - - - - - - - - -	31.00000	31.00000	31.00000	31.00000	31.00000	31.00000	31.00000	31.00000	31.00000
TRANSPORT - - - - - - - - - -	8.83000	8.83000	8.83000	8.83000	8.83000	8.83000	8.83000	8.83000	8.83000
PROCESS - - - - - - - - - - -	123.53000	123.53000	123.53000	123.53000	123.53000	123.53000	123.53000	123.53000	123.53000
UNITS TREATED- - - - - - - - -	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.
MISC. OPERATING EXPENSES - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COMMODITY DATA * * * * * * * *									
COBALT									
ORE GRADE - - - - - - - - -	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600
MILL RECOVERY - - - - - - -	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00
UNITS RECOVERED - - - - - -	5070.	5070.	5070.	5070.	5070.	5070.	5070.	5070.	5070.
REVENUES- - - - - - - - - -	130501696.	130501696.	130501696.	130501696.	130501696.	130501696.	130501696.	130501696.	130501696.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

SEVERANCE TAX	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER									
ORE GRADE	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400
MILL RECOVERY	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000
MILL CONCENTRATE GRADE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRICE/UNIT RECOVERED	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00
UNITS RECOVERED	28704.	28704.	28704.	28704.	28704.	28704.	28704.	28704.	28704.
REVENUES	40472640.	40472640.	40472640.	40472640.	40472640.	40472640.	40472640.	40472640.	40472640.
DEPLETION	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.
NICKEL									
ORE GRADE	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300
MILL RECOVERY	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000
MILL CONCENTRATE GRADE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00
UNITS RECOVERED	36708.	36708.	36708.	36708.	36708.	36708.	36708.	36708.	36708.
REVENUES	262645760.	262645760.	262645760.	262645760.	262645760.	262645760.	262645760.	262645760.	262645760.
DEPLETION	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.
MANGANESE									
ORE GRADE	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000
MILL RECOVERY	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000
MILL CONCENTRATE GRADE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00
UNITS RECOVERED	353760.	353760.	353760.	353760.	353760.	353760.	353760.	353760.	353760.
REVENUES	146810368.	146810368.	146810368.	146810368.	146810368.	146810368.	146810368.	146810368.	146810368.

DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

FINANCIAL SUMMARY * * * * * *

CASH FLOW

EXPENSED EXPLORATION +									
TOTAL REVENUES- - - - - - -	580430336.	580430336.	580430336.	580430336.	580430336.	580430336.	580430336.	580430336.	580430336.
LESS MINE OPERATING COSTS -	93000000.	93000000.	93000000.	93000000.	93000000.	93000000.	93000000.	93000000.	93000000.
LESS TRAN OPERATING COSTS -	26489984.	26489984.	26489984.	26489984.	26489984.	26489984.	26489984.	26489984.	26489984.
LESS PROCESS OPERATING COSTS	370589952.	370589952.	370589952.	370589952.	370589952.	370589952.	370589952.	370589952.	370589952.
LESS TRANS TO MARKET- - - -	18194736.	18194736.	18194736.	18194736.	18194736.	18194736.	18194736.	18194736.	18194736.
LESS EXPLORATION COSTS- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEVELOPMENT COSTS- - -	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.
LESS LOAN INT. PAYMENTS - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEPRECIATION - - - - - -	125850000.	125850000.	125850000.	125850000.	94354992.	70130000.	50700000.	31270000.	13240000.
LESS TOTAL ROYALTY PAYMENTS-	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUALS NET INCOME - - - - -	-61534976.	-61534976.	-61534976.	-61534976.	-30040064.	-5815040.	13615104.	33044992.	51075072.
PLUS DEPRECIATION - - - - -	125850000.	125850000.	125850000.	125850000.	94354992.	70130000.	50700000.	31270000.	13240000.
PLUS TOTAL DEPLETION USED -	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLUS DEFFERED DEDUCTIONS- -	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.
LESS EQUITY INVESTMENT- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUALS CASH FLOW- - - - - -	72156240.	72156240.	72156240.	72156240.	72156144.	72156176.	72156320.	72156208.	72156288.

ANALYSIS FIGURES

CONTINUOUS RATE OF RETURN -	-19.538	-15.927	-13.142	-10.934	-9.145	-7.672	-6.439	-5.396	-4.505
NOTE - * INDICATES THAT A DUAL RATE OF RETURN EXISTED IN THAT YEAR									
18.00 PCT PRESENT VALUE- -	-361173760.	-359013376.	-357208832.	-355701504.	-354442496.	-353390848.	-352512512.	-351778816.	-351165952.

15

	28	29	30	31	32	33	34
GENERAL DATA * * * * * * * * *							
INVESTMENTS							
EXPLORATION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
LAND ACQUISITION- - - - - -	0.	0.	0.	0.	0.	0.	0.
RESEACH & DEVELOPMENT,- - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 1- MINE- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 2- TRAN- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 4- PROC- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 5- PROC- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 6- PROC- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
EQUITY CAPITAL- - - - - - -	0.	0.	0.	0.	0.	0.	0.
WORKING CAPITAL - - - - - -	0.	0.	0.	0.	0.	0.	0.
OPERATING COSTS PER UNIT							
MINE- - - - - - - - - - - - -	31.00000	31.00000	31.00000	31.00000	31.00000	28.89999	3.33000
TRANSPORT - - - - - - - - - -	8.83000	8.83000	8.83000	8.83000	8.83000	8.83000	0.80000
PROCESS - - - - - - - - - - -	123.53000	123.53000	123.53000	123.53000	123.53000	123.53000	11.80000
UNITS TREATED- - - - - - - - -	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.	1500000.
MISC. OPERATING EXPENSES - - -	0.	0.	0.	0.	0.	0.	0.
COMMODITY DATA * * * * * * * *							
COBALT							
ORE GRADE - - - - - - - - -	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600	0.002600
MILL RECOVERY - - - - - - -	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000	0.650000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED							
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED							
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00	25740.00
UNITS RECOVERED - - - - - - -	5070.	5070.	5070.	5070.	5070.	5070.	2535.
REVENUES- - - - - - - - - -	130501696.	130501696.	130501696.	130501696.	130501696.	130501696.	65250880.
DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.

SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.
COPPER							
ORE GRADE - - - - - - - - -	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400	0.010400
MILL RECOVERY - - - - - - -	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED							
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED							
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRICE/UNIT RECOVERED- - - -	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00	1410.00
UNITS RECOVERED - - - - - -	28704.	28704.	28704.	28704.	28704.	28704.	14352.
REVENUES- - - - - - - - - -	40472640.	40472640.	40472640.	40472640.	40472640.	40472640.	20236320.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.
NICKEL							
ORE GRADE - - - - - - - - -	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300	0.013300
MILL RECOVERY - - - - - - -	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000	0.920000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED							
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED							
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00	7155.00
UNITS RECOVERED - - - - - -	36708.	36708.	36708.	36708.	36708.	36708.	18354.
REVENUES- - - - - - - - - -	262645760.	262645760.	262645760.	262645760.	262645760.	262645760.	131322864.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.
MANGANESE							
ORE GRADE - - - - - - - - -	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000	0.268000
MILL RECOVERY - - - - - - -	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000	0.440000
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED							
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED							
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.000	46.000	46.000	46.000	46.000	46.000	46.000
PRICE/UNIT RECOVERED- - - -	415.00	415.00	415.00	415.00	415.00	415.00	415.00
UNITS RECOVERED - - - - - -	353760.	353760.	353760.	353760.	353760.	353760.	176880.
REVENUES- - - - - - - - - -	146810368.	146810368.	146810368.	146810368.	146810368.	146810368.	73405168.

DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.

FINANCIAL SUMMARY * * * * * *

CASH FLOW							
EXPENSED EXPLORATION +							
TOTAL REVENUES- - - - - - -	580430336.	580430336.	580430336.	580430336.	580430336.	580430336.	290215168.
LESS MINE OPERATING COSTS -	93000000.	93000000.	93000000.	93000000.	93000000.	86699968.	4994999.
LESS TRAN OPERATING COSTS -	26489984.	26489984.	26489984.	26489984.	26489984.	26489984.	1200000.
LESS PROCESS OPERATING COSTS	370589952.	370589952.	370589952.	370589952.	370589952.	370589952.	17700000.
LESS TRANS TO MARKET- - - -	18194736.	18194736.	18194736.	18194736.	18194736.	18194736.	9097370.
LESS EXPLORATION COSTS- - -	0.	0.	0.	0.	0.	0.	0.
LESS DEVELOPMENT COSTS- - -	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.	3920610.
LESS LOAN INT. PAYMENTS - -	0.	0.	0.	0.	0.	0.	0.
LESS DEPRECIATION - - - - -	0.	0.	0.	0.	0.	0.	0.
LESS TOTAL ROYALTY PAYMENTS-	0.	0.	0.	0.	0.	0.	0.
EQUALS NET INCOME - - - - -	64314880.	64314880.	64314880.	64314880.	64314880.	70614784.	253302192.
PLUS DEPRECIATION - - - - -	0.	0.	0.	0.	0.	0.	0.
PLUS TOTAL DEPLETION USED -	0.	0.	0.	0.	0.	0.	0.
PLUS DEFFERED DEDUCTIONS- -	7841220.	7841220.	7841220.	7841220.	7841220.	7841220.	3920610.
LESS EQUITY INVESTMENT- - -	0.	0.	0.	0.	0.	0.	0.
EQUALS CASH FLOW- - - - - -	72156096.	72156096.	72156096.	72156096.	72156096.	78456000.	257222800.

ANALYSIS FIGURES							
CONTINUOUS RATE OF RETURN -	-3.735	-3.066	-2.480	-1.963	-1.506	-1.065	0.066
NOTE - * INDICATES THAT A DUAL RATE OF RETURN EXISTED IN THAT YEAR							
18.00 PCT PRESENT VALUE- -	-350653952.	-350226432.	-349869312.	-349571072.	-349321728.	-349095424.	-348475648.

SUMMARY DATA

ENTERPRISE EVALUATION -3MILLION TONNES NODULES(DRY) P.A. [CUPRION PROCESS]

	LAST YEAR ADDITIONS TO CASH FLOW
CUMULATIVE WORKING CAPITAL	334599936.
CUMULATIVE SALVAGE VALUE	0.

	OTHER CUMULATIVE VALUES
REVENUES	12672692200.
ROYALTIES	0.
TOTAL DEPRECIATION	1258498560.
FEDERAL INCOME TAXES	0.
CASH FLOW	17558096.

	LAST YEARS ANALYSIS FIGURES
CONTINUOUS RATE OF RETURN	0.066
18.00 PCT PRESENT VALUE	-348475648.

COMMODITY SUMMARY DATA

COMMODITY	REVENUES	UNITS RECOVERED	PRICE/UNIT
COBALT	2849285630.	110694.	25740.000
COPPER	883651584.	626704.	1410.000
NICKEL	5734420480.	801458.	7155.000
MANGANESE	3205359360.	7723740.	415.000

TOTAL INITIAL INVESTMENT DATA

ITEM	AMOUNT
EXPLORATION	21000000.
LAND ACQUISITION	0.
RESEARCH & DEVELOPMENT	171200000.
MINE AND TRANS SHIPS	397799680.
PROCESS PLANT AND PORT	860699392.
WORKING CAPITAL	334599936.
MISC INVEST & OP COSTS	0.
TOTAL UNITS TREATED	65500000.

BUREAU OF MINERAL RESOURCES OF AUSTRALIA

FINANCIAL EVALUATION

ENTERPRISE EVALUATION SIMLTN. 3M.TONNES NODULES(DRY)P.A. [CUPRION PROCESS]

BEGINNING OPERATION IN 1
AND ENDING OPERATION IN 34
WITH 11 PREPRODUCTION YEARS
USING 150 SIMULATION(S) AND
A TARGET RATE OF RETURN OF
0.1 PERCENT
CONTINUOUS DISCOUNTED CASHFLOW IS USED

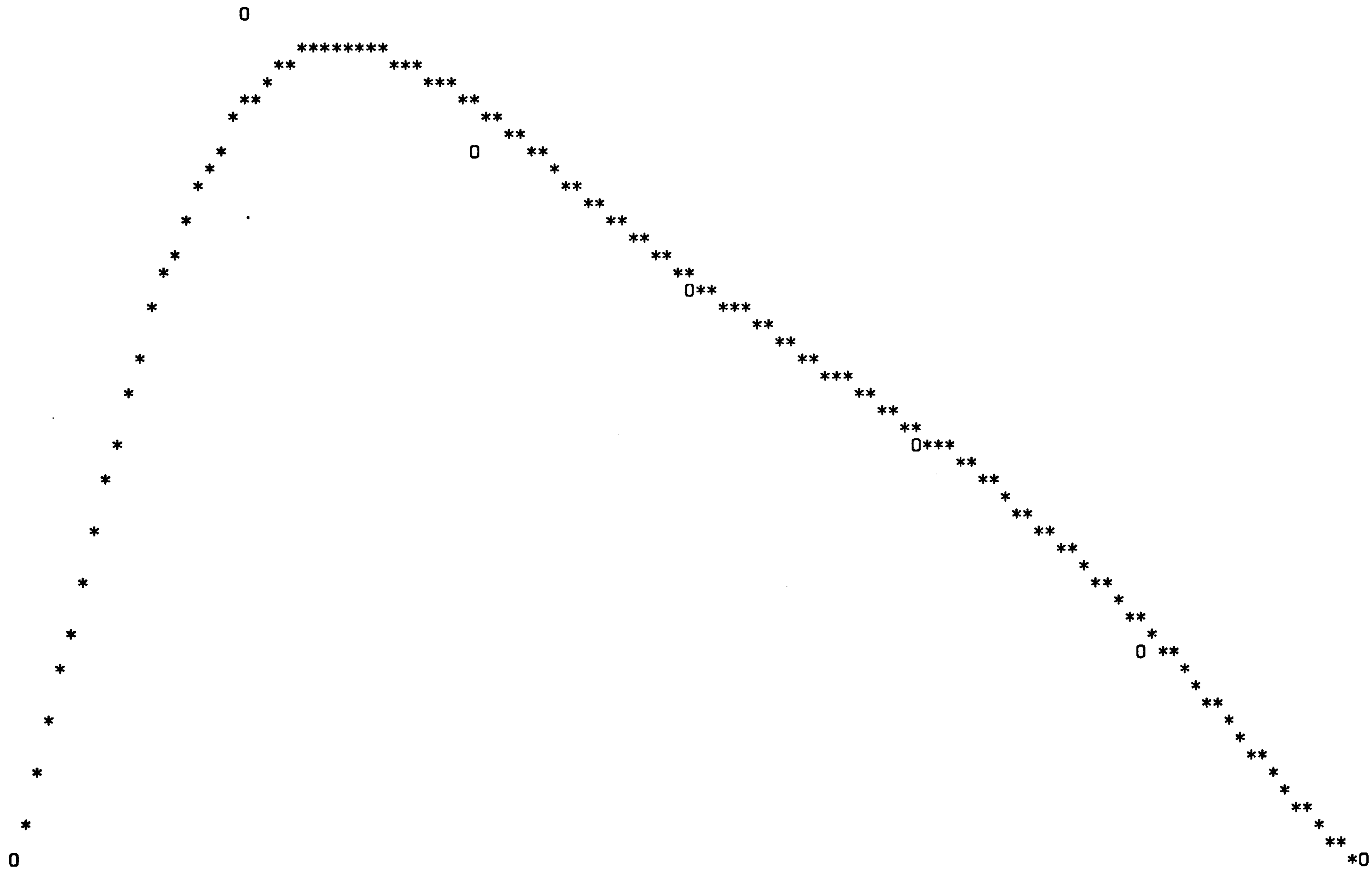
20

77

CATEGORY 1 EXPLORATION 1 TO 6

COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS

EQUATION COEFICIENTS, A= 10.4218750 , B= -0.00000171, C= 2.18872070, D= -2.37011719

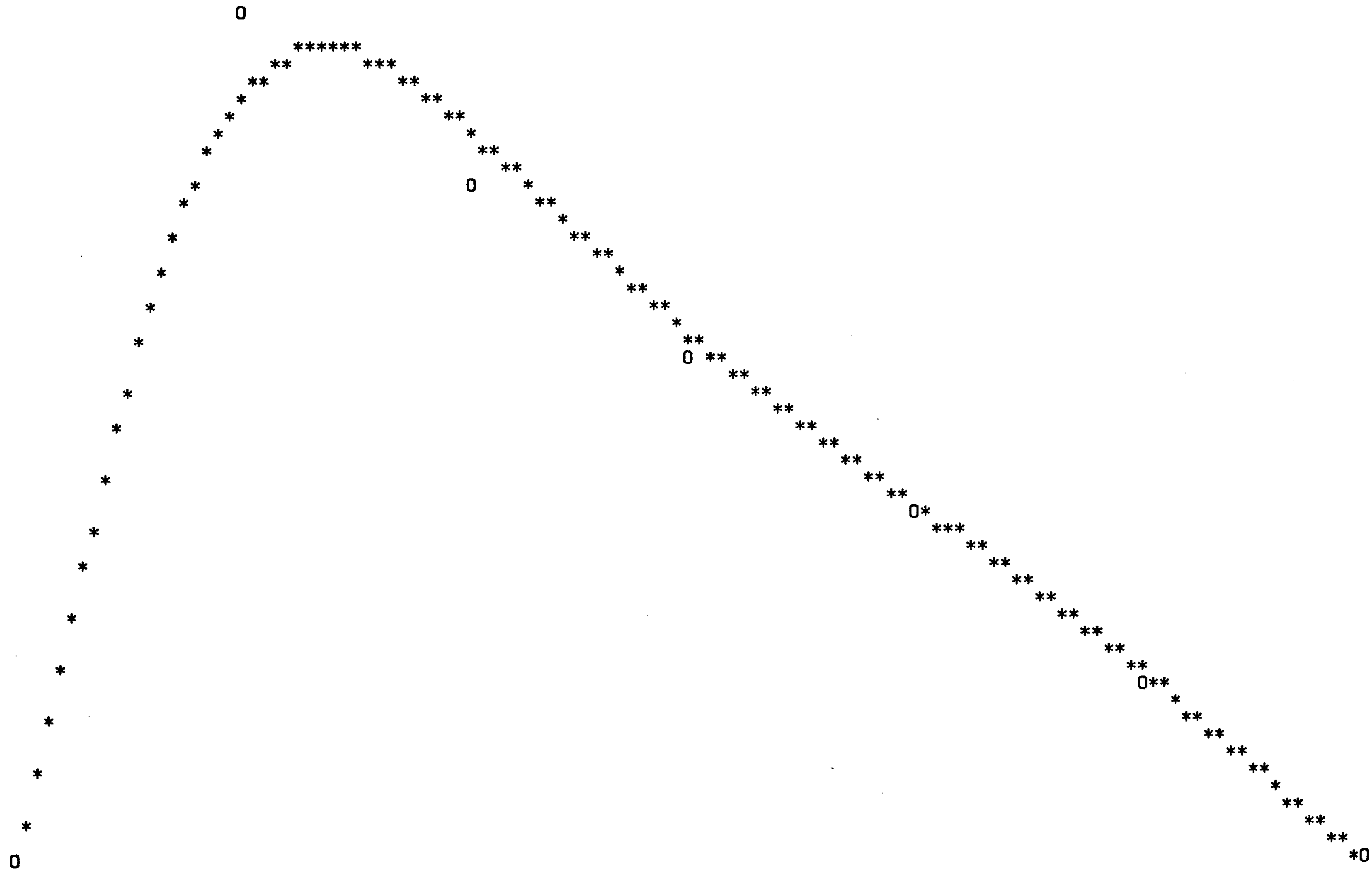


* = CALCULATED CURVE   0 = ADJUSTED INPUT DATA POINTS

21

78

CATEGORY 3 RESEARCH 1 TO 5
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= 8.29687500, B= -0.00000031, C= 2.16381836, D= -2.23803711

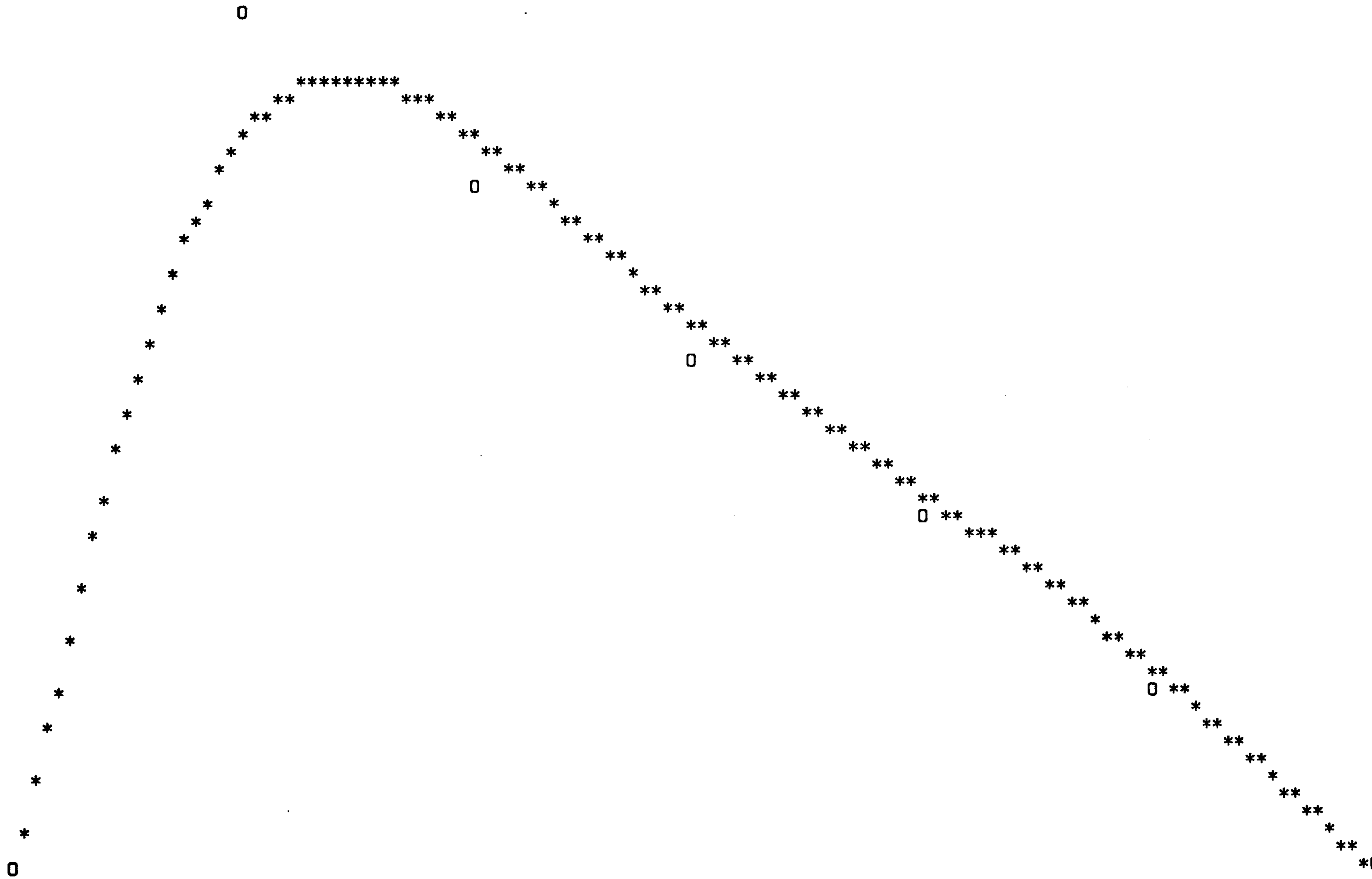


* = CALCULATED CURVE   0 = ADJUSTED INPUT DATA POINTS

CATEGORY 3 RESEARCH 6 TO 7

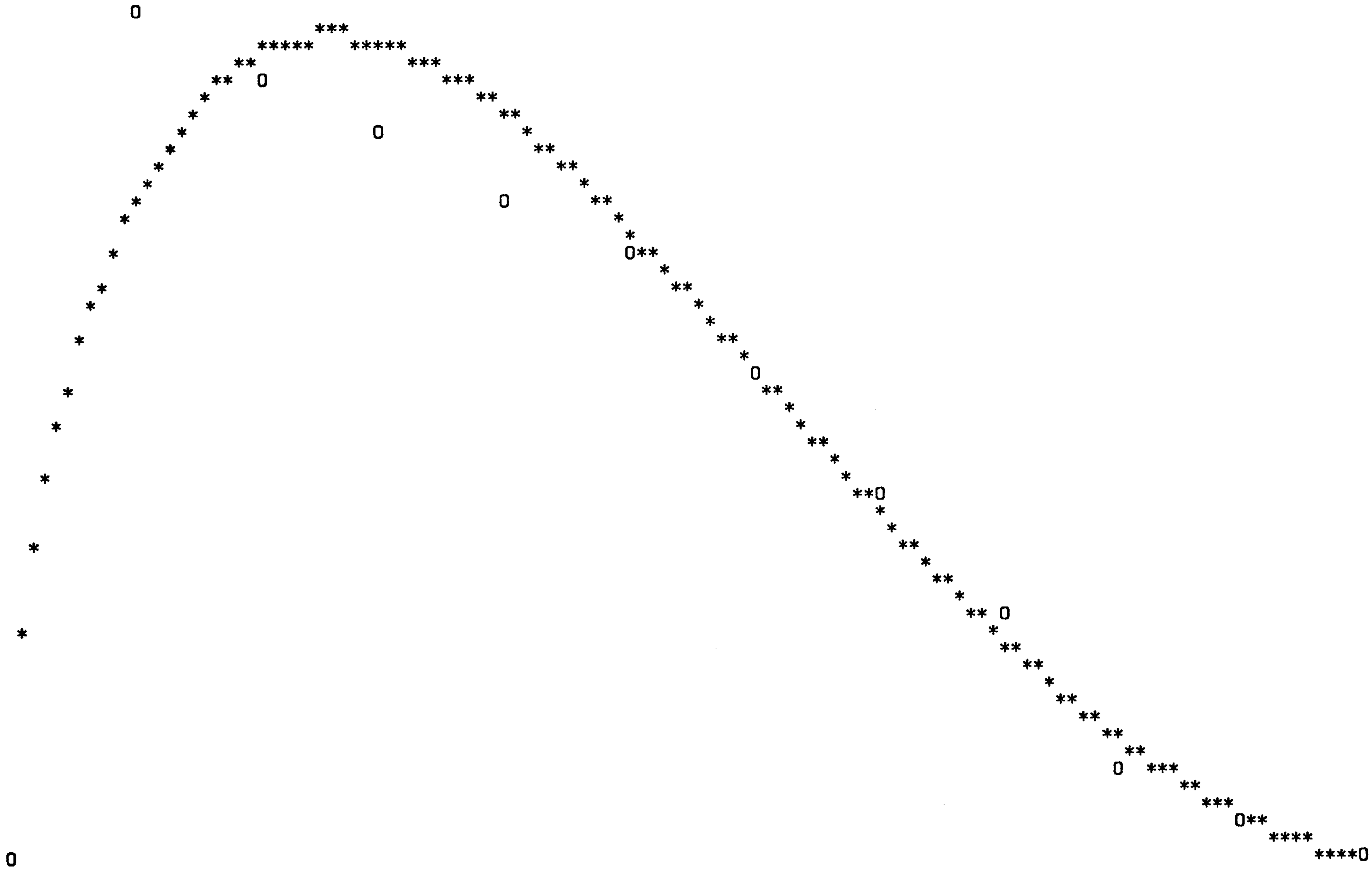
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS

EQUATION COEFICIENTS, A= 7.97265625, B= -0.00000012, C= 2.11914062, D= -2.19628906



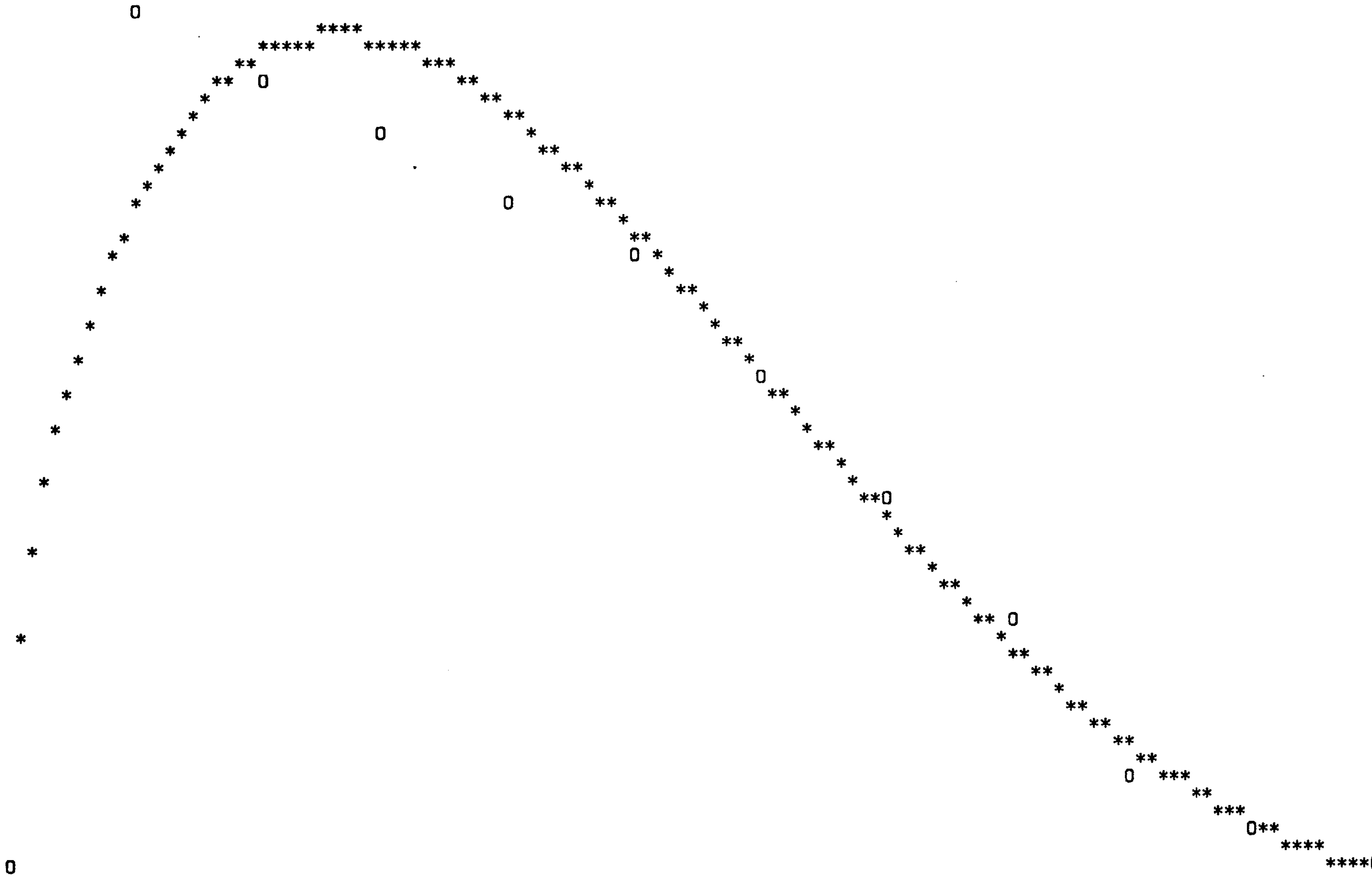
* = CALCULATED CURVE   0 = ADJUSTED INPUT DATA POINTS

CATEGORY 4 MINING CAP 7 TO 11
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= 22.2617187 , B= -0.00000003, C= 1.43066406, D= -2.56494141



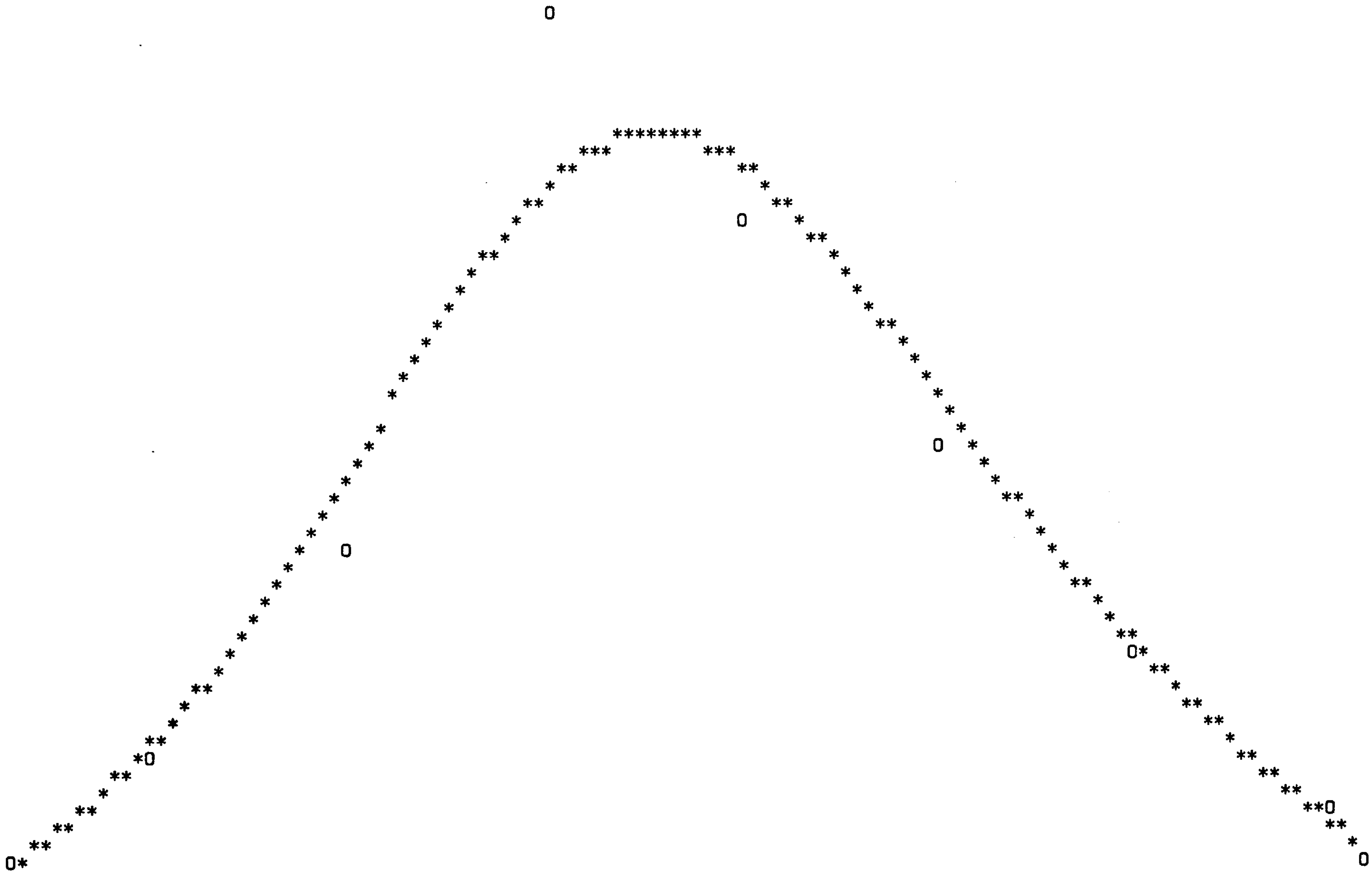
* = CALCULATED CURVE   0 = ADJUSTED INPUT DATA POINTS

CATEGORY 4 MINING CAP 12 TO 12
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= 22.5781250 , B= -0.00000002, C= 1.43115234, D= -2.55786133



* = CALCULATED CURVE 0 = ADJUSTED INPUT DATA POINTS

CATEGORY 7 PROCESS CAP1 9 TO 10
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= -7.82446289, B= 0.00000003, C= 2.02705383, D= -1.57582092

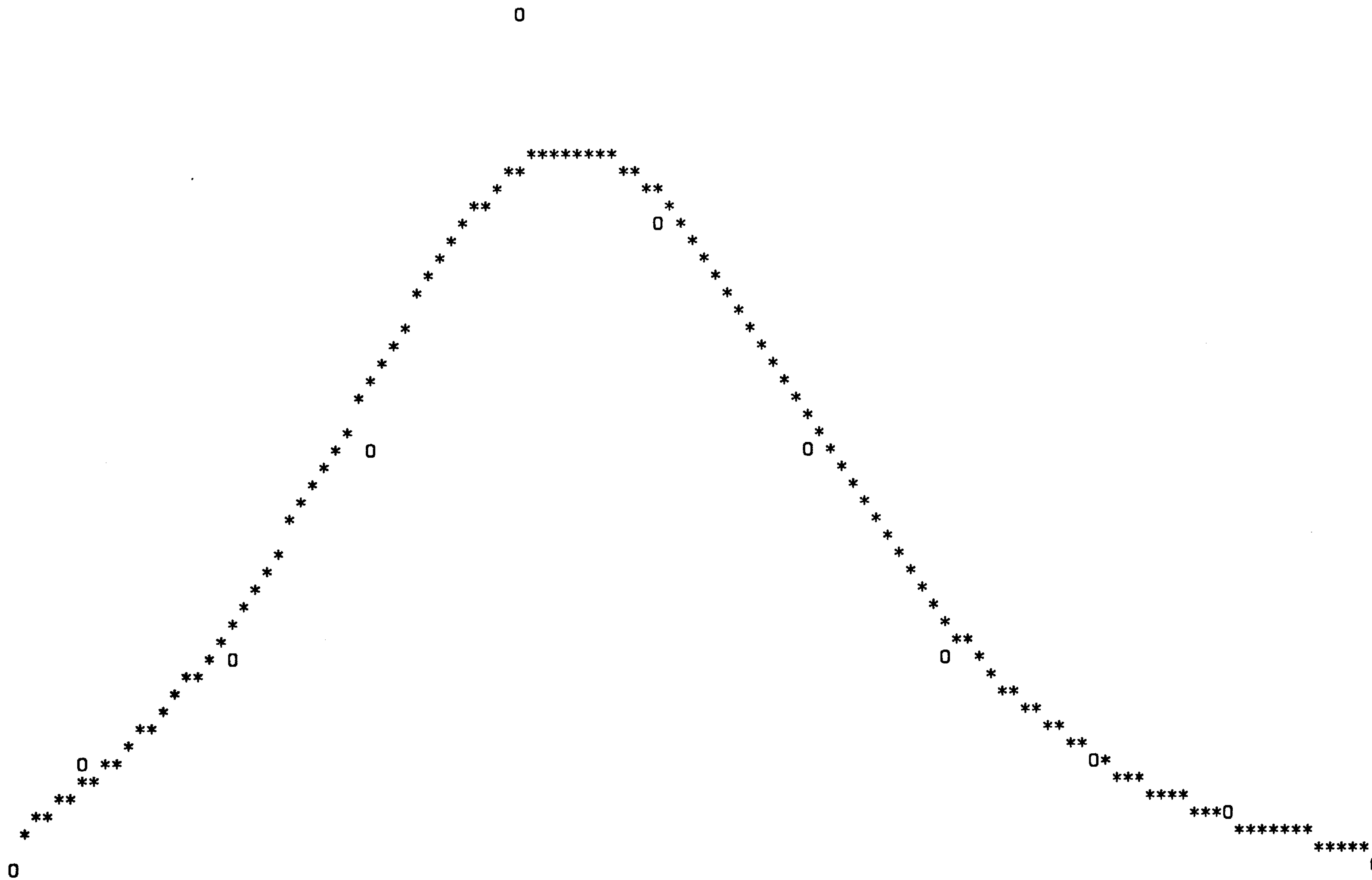


* = CALCULATED CURVE   0 = ADJUSTED INPUT DATA POINTS

CATEGORY 8 PROCESS CAP2 10 TO 11

COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS

EQUATION COEFICIENTS, A= -8.07836914, B= 0.00000039, C= 1.29109192, D= -1.03981018



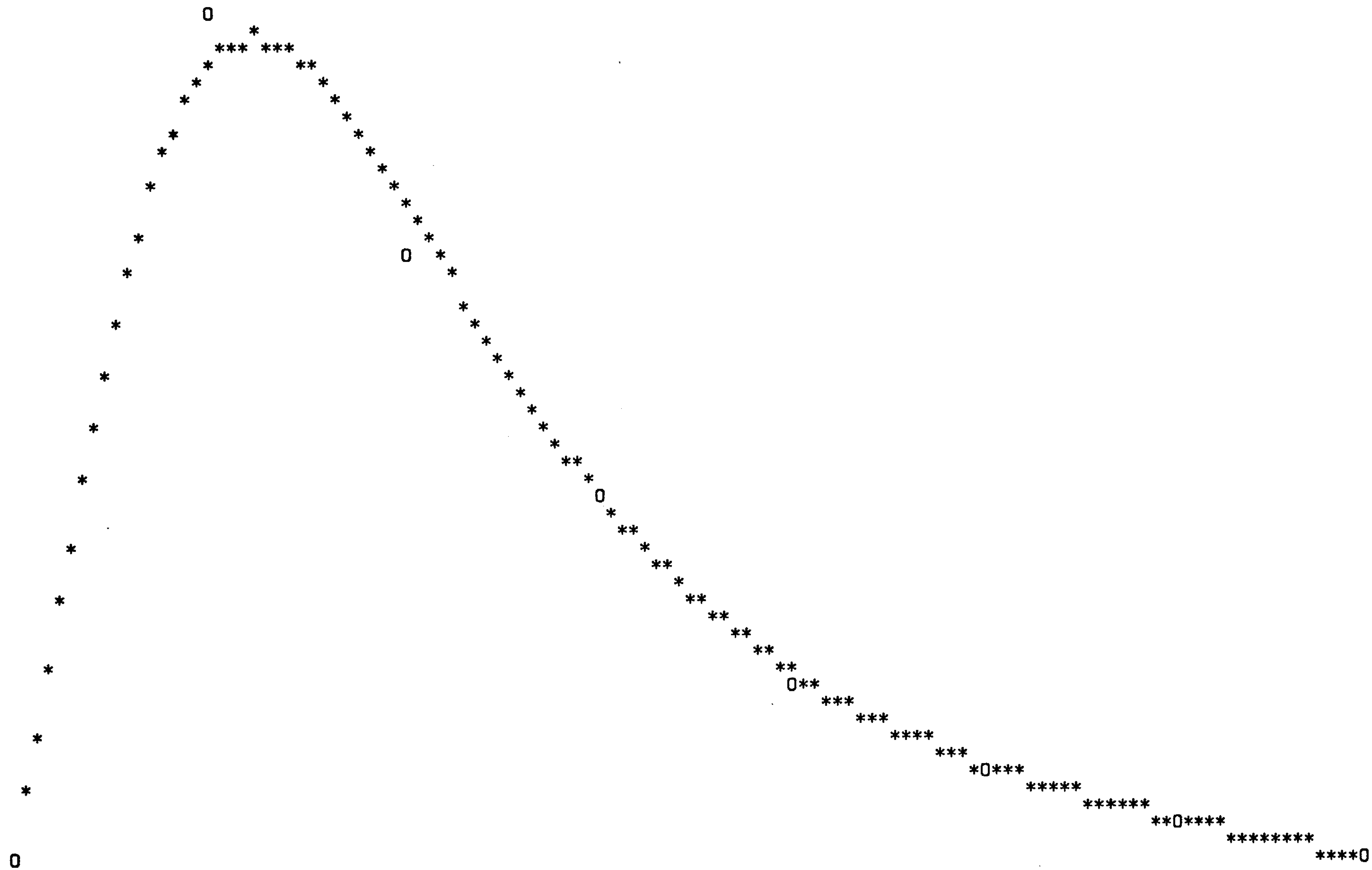
* = CALCULATED CURVE 0 = ADJUSTED INPUT DATA POINTS

78

CATEGORY 9 PROCESS CAP3 7 TO 12

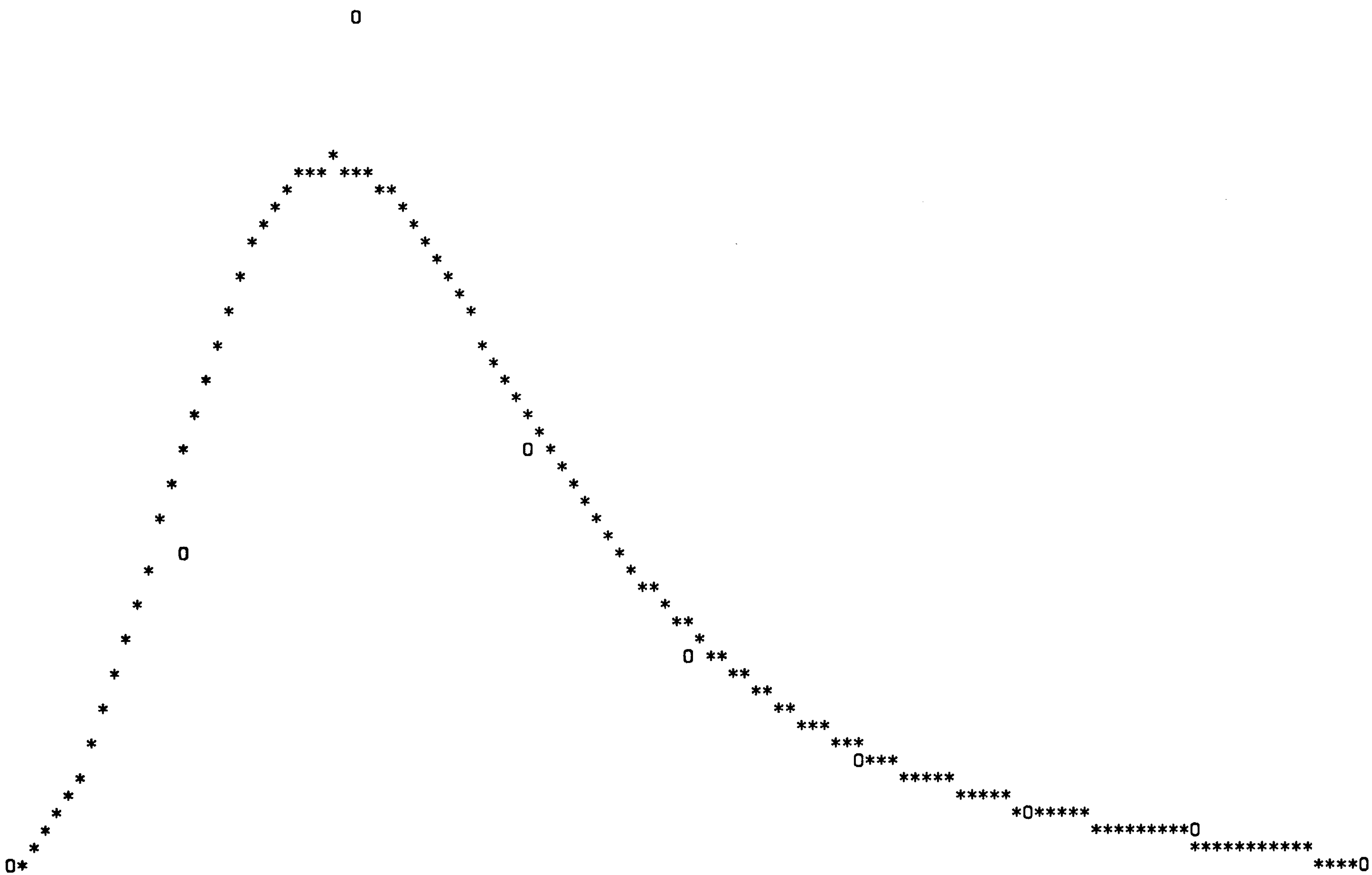
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS

EQUATION COEFICIENTS, A= 3.77734375, B= -0.00000001, C= 1.99438477, D= -1.97265625



* = CALCULATED CURVE   0 = ADJUSTED INPUT DATA POINTS

CATEGORY 15 OP COST MINE 12 TO 32
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= 1.31933594, B= -0.06655884, C= 2.80937195, D= -1.65628052

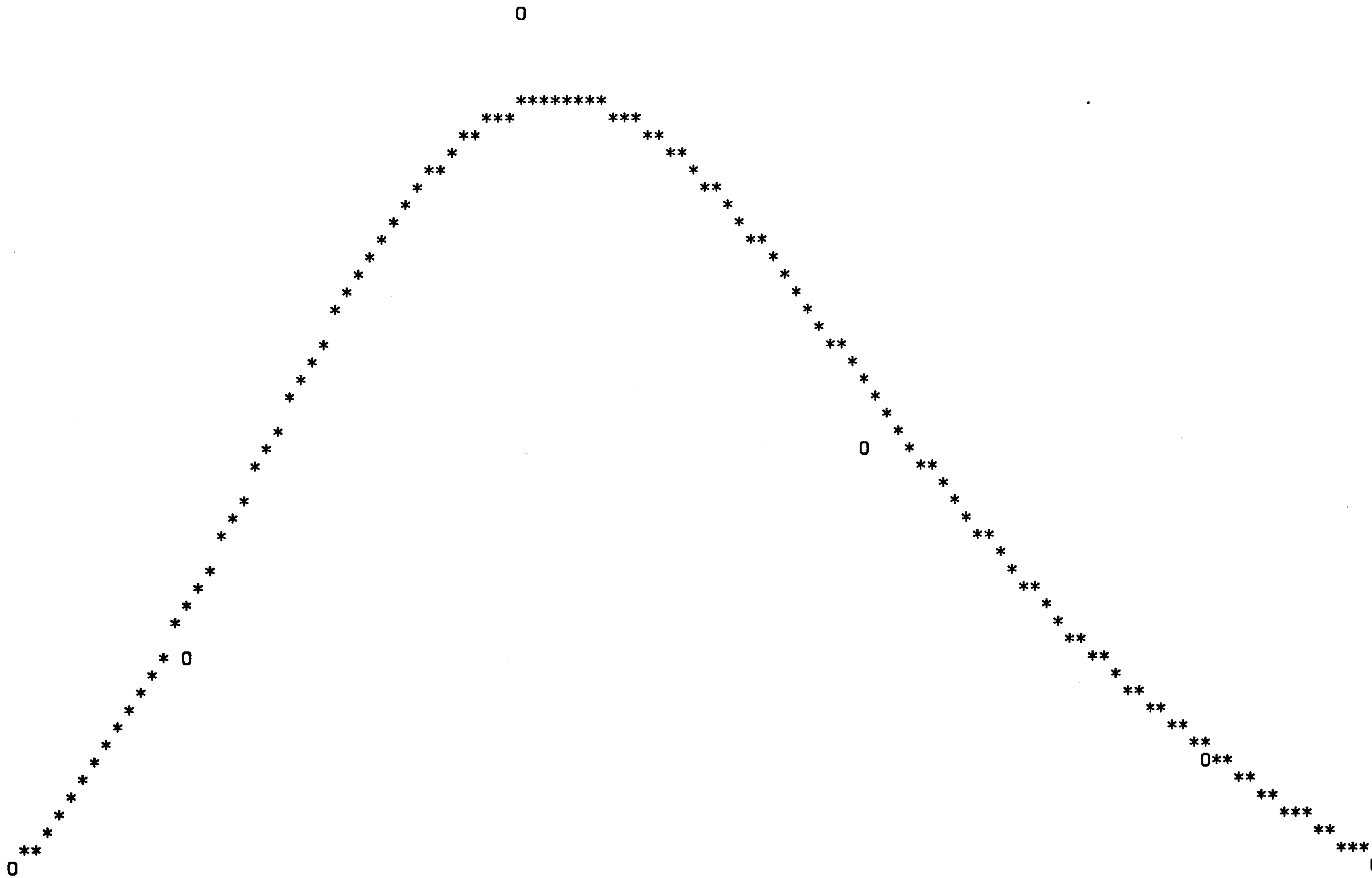


* = CALCULATED CURVE 0 = ADJUSTED INPUT DATA POINTS

CATEGORY 16 OP COST TRAN 12 TO 33

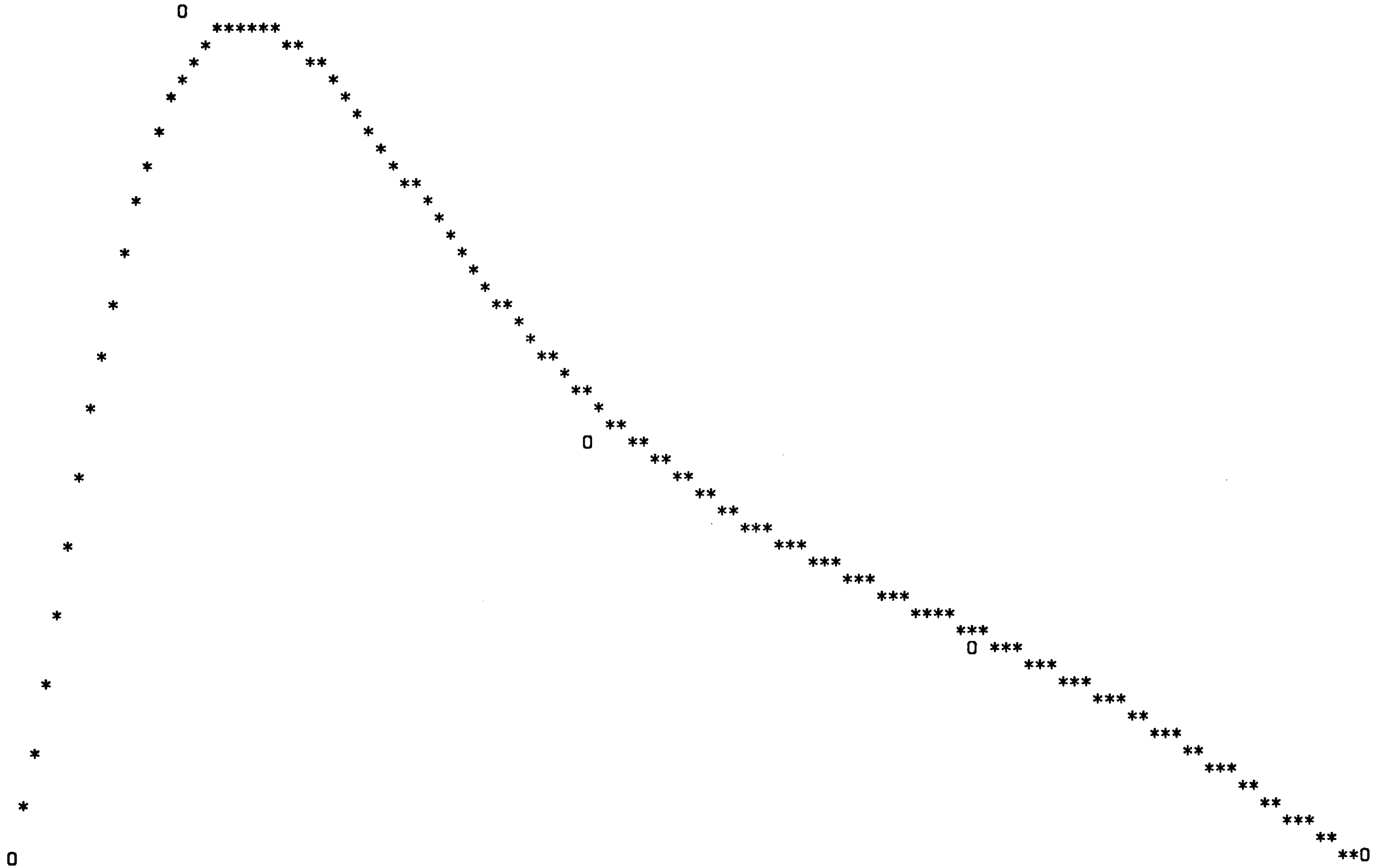
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS

EQUATION COEFICIENTS, A= 1.79467773, B= -0.16088867, C= 2.16586304, D= -1.82043457



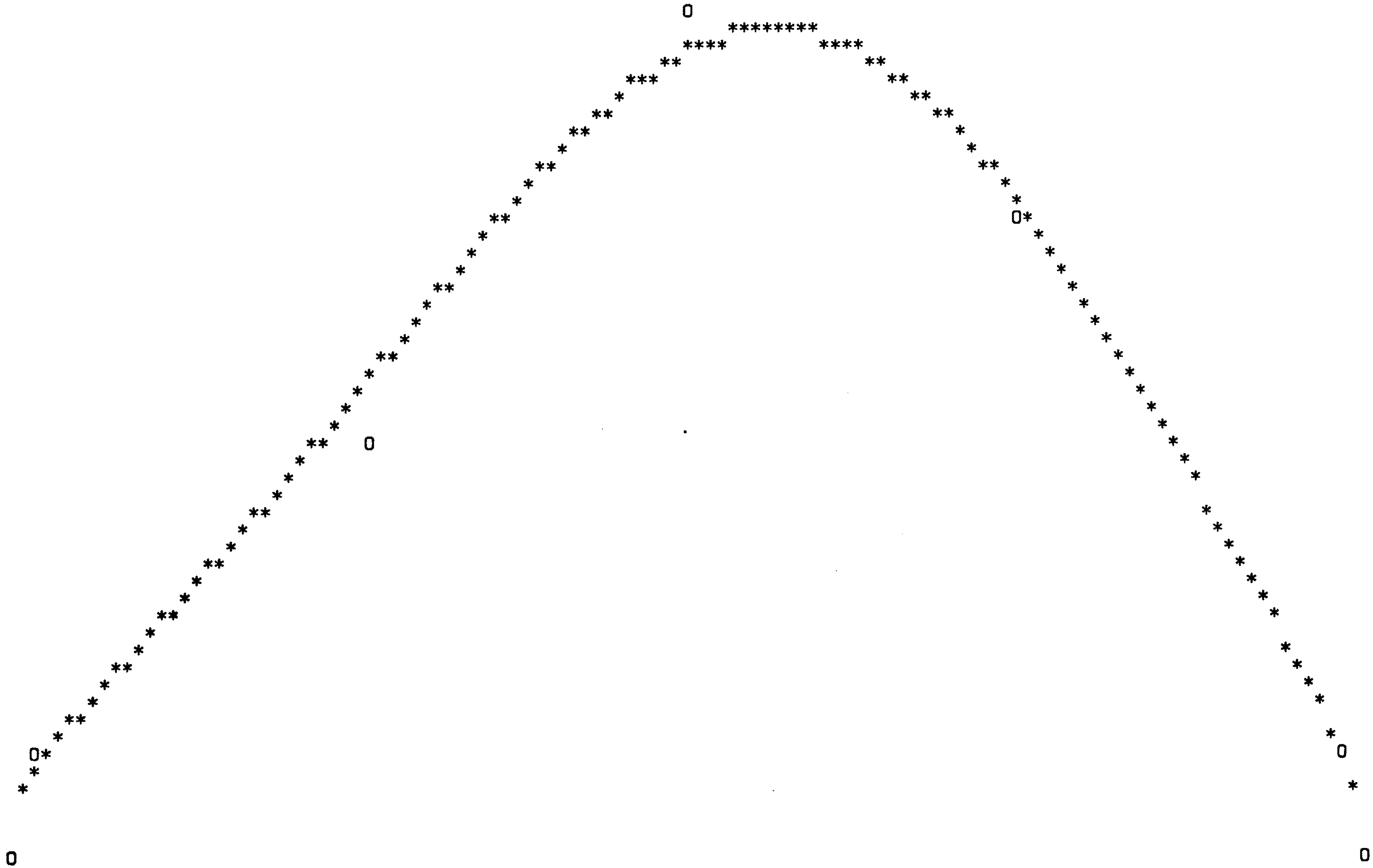
* = CALCULATED CURVE   0 = ADJUSTED INPUT DATA POINTS

CATEGORY 18 OP COST PROC 12 TO 33
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= 14.7971191 , B= -0.09486103, C= 2.23725891, D= -2.38272095



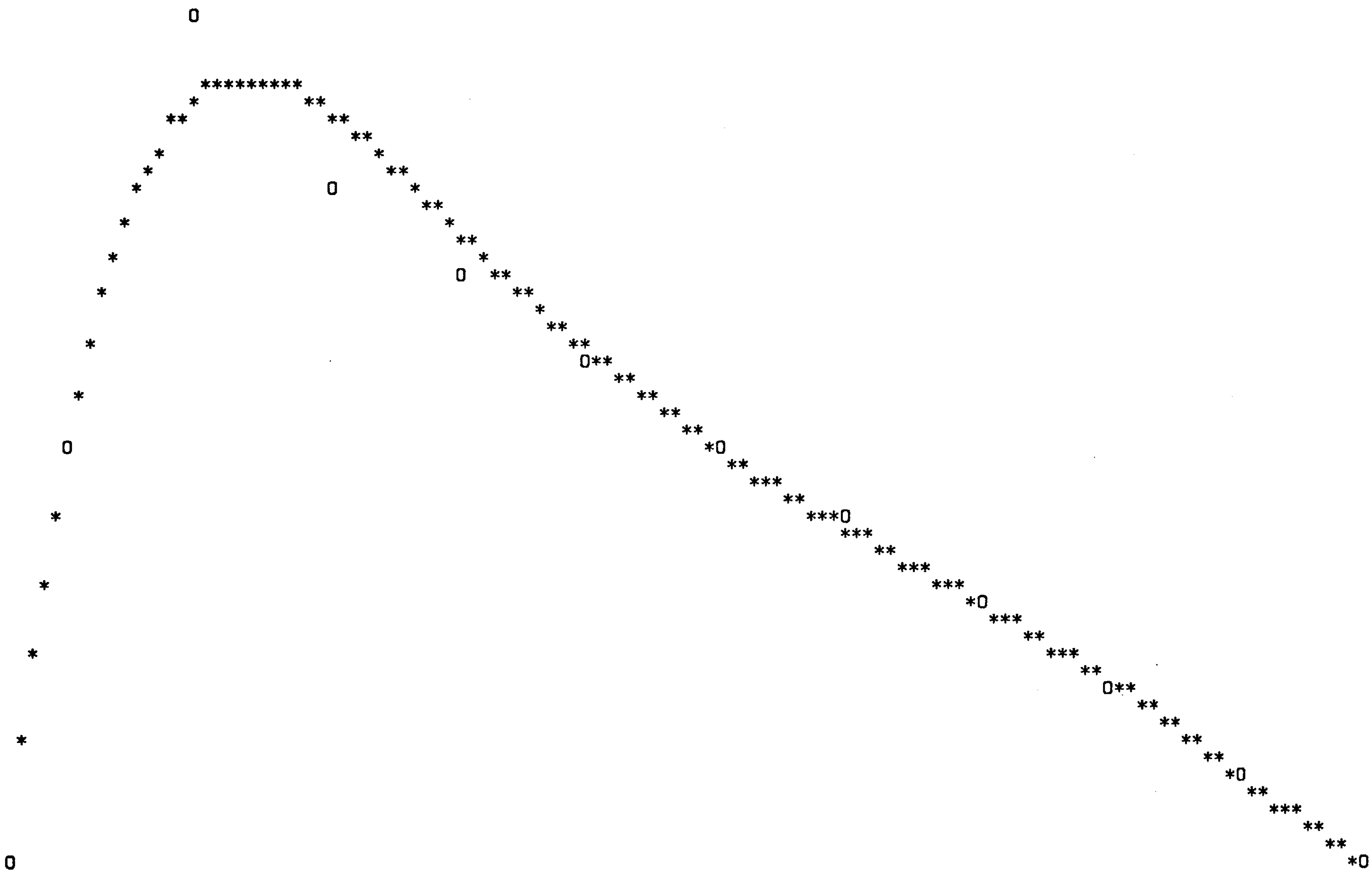
* = CALCULATED CURVE   0 = ADJUSTED INPUT DATA POINTS

CATEGORY 32 CO PRICE $/T 1 TO 34
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= 0.64076233, B= 0.00002072, C= 1.39499378, D= -1.54304504



* = CALCULATED CURVE 0 = ADJUSTED INPUT DATA POINTS

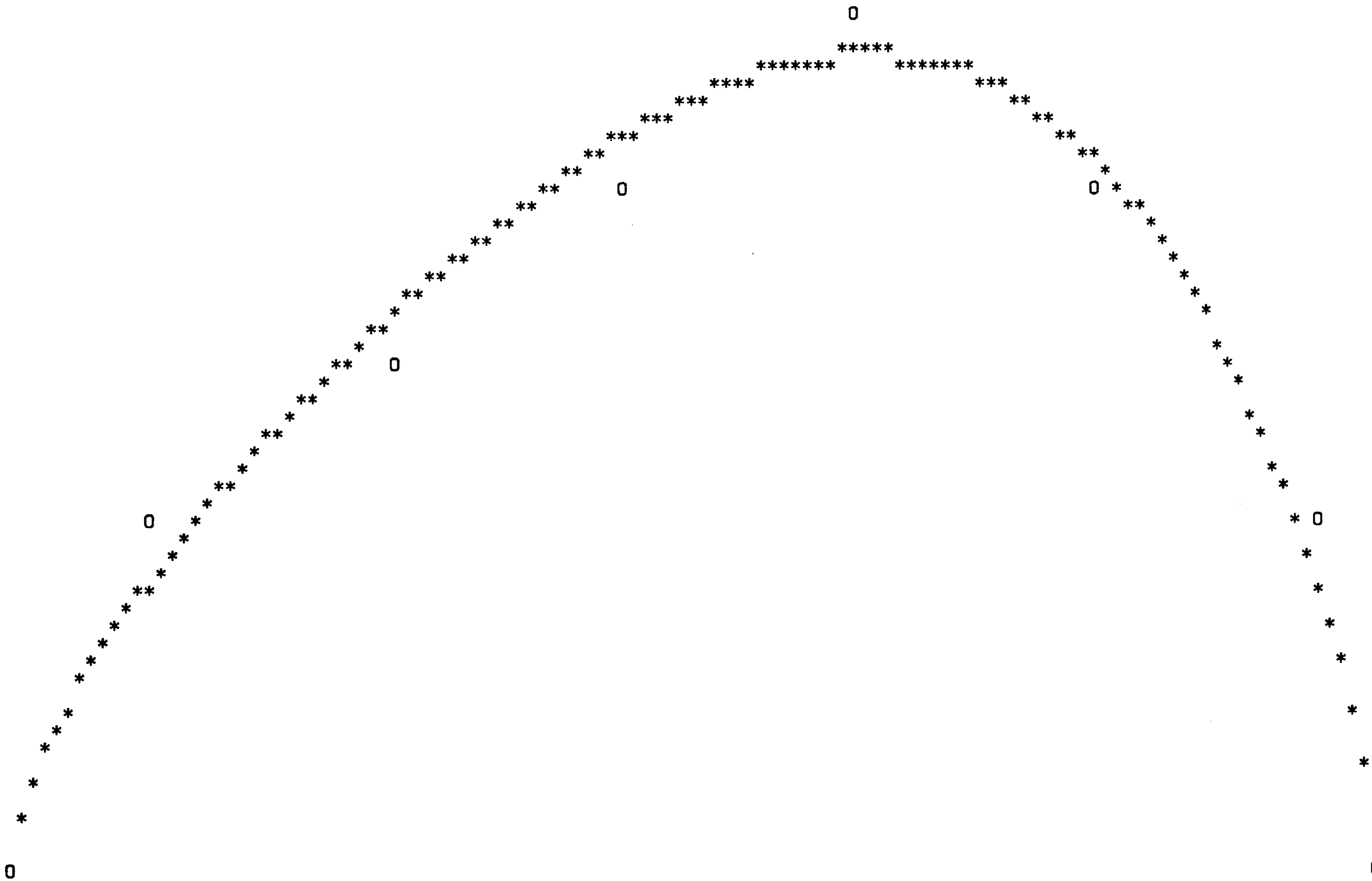
CATEGORY 44 CU PRICE $/T 1 TO 34
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= 6.96801758, B= -0.00184625, C= 1.82972717, D= -2.19046021



* = CALCULATED CURVE 0 = ADJUSTED INPUT DATA POINTS

90

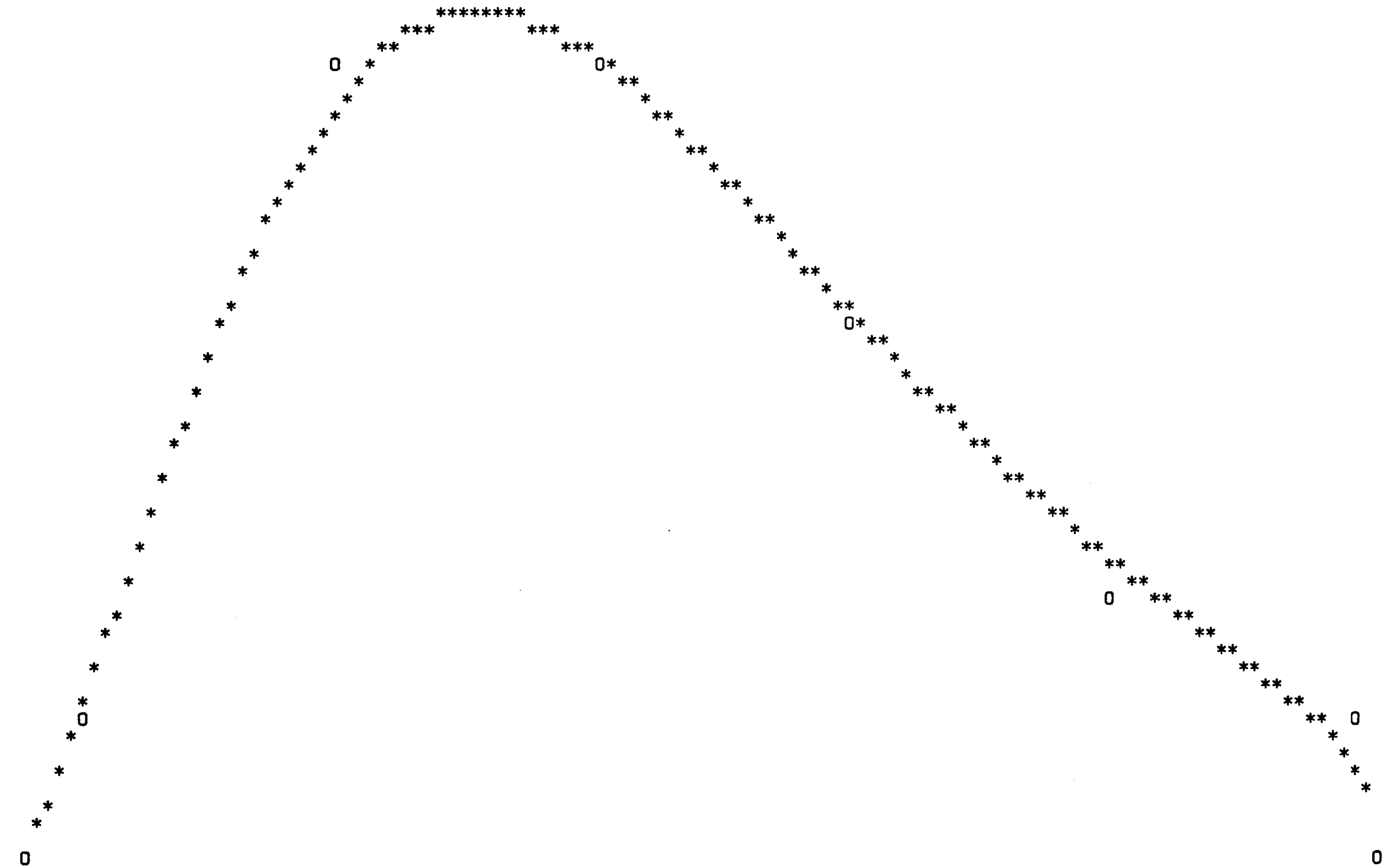
CATEGORY 56 NI PRICE $/T 1 TO 34
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= 1.38903809, B= -0.00021617, C= 1.60368347, D= -1.61451721



* = CALCULATED CURVE   0 = ADJUSTED INPUT DATA POINTS

CATEGORY 68 MN PRICE $/T 1 TO 34
COMPARISON OF CALCULATED CURVE WITH ADJUSTED INPUT DATA POINTS
EQUATION COEFICIENTS, A= -2.50025940, B= -0.00151819, C= 2.02924252, D= -1.31838512

91



* = CALCULATED CURVE 0 = ADJUSTED INPUT DATA POINTS

TAX PARAMETER LIST BY INPUT RECORD


```
COMMODITY RECORD FOR COBALT
     SEVERANCE TAX OPTION = NO SEVERANCE TAX
     FIXED SEVERANCE AMOUNT ($1000) =      0.0
     DEPLETION ALLOWANCE OPTION = NO DEPLETION
     DEPLETION ALLOWANCE =  0.0
     FIXED DEPLETION AMOUNT ($1000) =     0.0
     PAID-FOR PERCENTAGE =      1.000

COMMODITY RECORD FOR COPPER
     SEVERANCE TAX OPTION = NO SEVERANCE TAX
     FIXED SEVERANCE AMOUNT ($1000) =      0.0
     DEPLETION ALLOWANCE OPTION = NO DEPLETION
     DEPLETION ALLOWANCE =  0.0
     FIXED DEPLETION AMOUNT ($1000) =     0.0
     PAID-FOR PERCENTAGE =      1.000

COMMODITY RECORD FOR NICKEL
     SEVERANCE TAX OPTION = NO SEVERANCE TAX
     FIXED SEVERANCE AMOUNT ($1000) =      0.0
     DEPLETION ALLOWANCE OPTION = NO DEPLETION
     DEPLETION ALLOWANCE =  0.0
     FIXED DEPLETION AMOUNT ($1000) =     0.0
     PAID-FOR PERCENTAGE =      1.000

COMMODITY RECORD FOR MANGANESE
     SEVERANCE TAX OPTION = NO SEVERANCE TAX
     FIXED SEVERANCE AMOUNT ($1000) =      0.0
     DEPLETION ALLOWANCE OPTION = NO DEPLETION
     DEPLETION ALLOWANCE =  0.0
     FIXED DEPLETION AMOUNT ($1000) =     0.0
     PAID-FOR PERCENTAGE =      1.000
RATE OF RETURN IS LESS THAN MINUS 90 PCT IN YEAR   14
```

	1	2	3	4	5	6	7	8	9
GENERAL DATA * * * * * * * * *									
INVESTMENTS									
EXPLORATION - - - - - - - - -	4636500.	4434375.	3637218.	4884000.	4121905.	4529250.	0.	0.	0.
LAND ACQUISITION- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
RESEACH & DEVELOPMENT,- - -	19108512.	16904880.	23400208.	19398560.	21296144.	48078592.	47328864.	0.	0.
INVEST. NUMBER 1- MINE- - -	0.	0.	0.	0.	0.	0.	50558048.	56359600.	53761120.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	10	10	10
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 2- TRAN- - -	0.	0.	0.	0.	0.	0.	14304591.	14515873.	12998695.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	10	10	10
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 4- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	23936128.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	0	0	10
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 5- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 6- PROC- - -	0.	0.	0.	0.	0.	0.	124607312.	197358720.	131978096.
LIFE - - - - - - - - - - -	0	0	0	0	0	0	10	10	10
DEPRECIATION - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUITY CAPITAL- - - - - - -	19108512.	16904880.	23400208.	19398560.	21296144.	48078592.	236798800.	268234192.	222674032.
WORKING CAPITAL - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPERATING COSTS PER UNIT									
MINE- - - - - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRANSPORT - - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PROCESS - - - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNITS TREATED- - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
MISC. OPERATING EXPENSES - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COMMODITY DATA * * * * * * * *									
COBALT									
ORE GRADE - - - - - - - - -	0.002582	0.002532	0.002572	0.002393	0.002629	0.002649	0.002618	0.002567	0.002411
MILL RECOVERY - - - - - - -	0.638808	0.646908	0.666939	0.624816	0.636798	0.658619	0.649327	0.642717	0.641631
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.807	43.140	34.470	37.856	34.185	39.594	59.408	38.707	35.572
PRICE/UNIT RECOVERED- - - -	33072.19	28338.75	31680.00	25542.77	19434.55	35670.94	21482.23	24278.20	18094.57
UNITS RECOVERED - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
REVENUES- - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER									
ORE GRADE - - - - - - - - -	0.010500	0.010535	0.010662	0.010459	0.010652	0.010421	0.010486	0.010621	0.010352
MILL RECOVERY - - - - - - -	0.906565	0.920390	0.929843	0.922356	0.922804	0.918072	0.915576	0.920195	0.920270
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SMELTER CONCENTRATE GRADE -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REFINER RECOVERY- - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REFINER- - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TO REFINERY- - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TO MARKET- - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRICE/UNIT RECOVERED- - - -	1347.52	1281.71	1859.52	1712.88	1669.24	2240.08	1575.53	1911.03	2148.52
UNITS RECOVERED - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
REVENUES- - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
NICKEL									
ORE GRADE - - - - - - - - -	0.013760	0.013562	0.013722	0.012416	0.012633	0.013512	0.013747	0.013479	0.013450
MILL RECOVERY - - - - - - -	0.917484	0.924293	0.924929	0.915118	0.922084	0.917636	0.916813	0.922121	0.906772
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	40.176	46.654	49.322	39.058	56.642	38.561	60.977	49.933	43.206
PRICE/UNIT RECOVERED- - - -	8031.29	7716.97	7612.88	7578.18	6953.63	6829.13	6053.54	7010.78	8986.48
UNITS RECOVERED - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
REVENUES- - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
MANGANESE									
ORE GRADE - - - - - - - - -	0.272820	0.274034	0.266388	0.269174	0.258943	0.259711	0.251954	0.263992	0.280117
MILL RECOVERY - - - - - - -	0.479631	0.505176	0.468326	0.427399	0.422174	0.495561	0.470486	0.534407	0.394924
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	32.610	33.203	40.175	55.697	61.305	31.380	49.824	41.033	37.787
PRICE/UNIT RECOVERED- - - -	536.50	396.32	464.96	669.06	592.58	582.27	522.11	606.33	585.70
UNITS RECOVERED - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
REVENUES- - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
FINANCIAL SUMMARY * * * * * *									
CASH FLOW									
EXPENSED EXPLORATION + TOTAL REVENUES- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS MINE OPERATING COSTS -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS TRAN OPERATING COSTS -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS PROCESS OPERATING COSTS	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS TRANS TO MARKET- - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS EXPLORATION COSTS- - -	4636500.	4434375.	3637218.	4884000.	4121905.	4529250.	0.	0.	0.
LESS DEVELOPMENT COSTS- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS LOAN INT. PAYMENTS - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEPRECIATION - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS TOTAL ROYALTY PAYMENTS-	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUALS NET INCOME - - - - -	-4636500.	-4434375.	-3637218.	-4884000.	-4121905.	-4529250.	0.	0.	0.
PLUS DEPRECIATION - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLUS TOTAL DEPLETION USED -	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLUS DEFFERED DEDUCTIONS- -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS EQUITY INVESTMENT- - -	19108512.	16904880.	23400208.	19398560.	21296144.	48078592.	236798800.	268234192.	222674032.
EQUALS CASH FLOW- - - - - -	-23745008.	-21339248.	-27037424.	-24282560.	-25418048.	-52607840.	-236798800.	-268234192.	-222674032.
ANALYSIS FIGURES									
CONTINUOUS RATE OF RETURN -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NOTE - * INDICATES THAT A DUAL RATE OF RETURN EXISTED IN THAT YEAR									
0.10 PCT PRESENT VALUE- -	-23730864.	-45036080.	-72003424.	-96198816.	-121500320.	-173814624.	-409056512.	-675260928.	-896028928.

	10	11	12	13	14	15	16	17	18
GENERAL DATA * * * * * * * * *									
INVESTMENTS									
EXPLORATION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAND ACQUISITION- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
RESEACH & DEVELOPMENT,- - -	0.	3200000.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 1- MINE- - -	78716864.	64103616.	110321840.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	10	10	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	16087988.	21723936.	27100048.	34971728.	41382080.	41382080.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 2- TRAN- - -	13117831.	15003080.	14066123.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	10	10	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	2930767.	5788966.	7088835.	8400618.	8400618.	8400618.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 4- PROC- - -	20555712.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	2393612.	4449183.	4449183.	4449183.	4449183.	4449183.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 5- PROC- - -	12264905.	9544535.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	10	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	1226490.	2180943.	2180943.	2180943.	2180943.	2180943.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 6- PROC- - -	178895120.	161065056.	139637312.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - - -	10	10	10	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	12460731.	32196592.	45394400.	63283904.	79390400.	93354128.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUITY CAPITAL- - - - - - -	303550208.	252916272.	264025264.	334599936.	0.	0.	0.	0.	0.
WORKING CAPITAL - - - - - -	0.	0.	0.	334599936.	0.	0.	0.	0.	0.
OPERATING COSTS PER UNIT									
MINE- - - - - - - - - - - - -	0.0	0.0	28.37518	33.95462	28.68703	42.04370	33.15538	31.76884	30.25519
TRANSPORT - - - - - - - - - -	0.0	0.0	7.97064	7.77328	8.73723	8.09689	8.69758	8.61312	10.14371
PROCESS - - - - - - - - - - -	0.0	0.0	121.92805	154.29471	141.70424	125.34489	127.58138	121.91508	136.52721
UNITS TREATED- - - - - - - - -	0.	0.	1500000.	2500000.	3000000.	3000000.	3000000.	3000000.	3000000.
MISC. OPERATING EXPENSES - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COMMODITY DATA * * * * * * * *									
COBALT									
ORE GRADE - - - - - - - - -	0.002481	0.002642	0.002596	0.002631	0.002589	0.002532	0.002438	0.002557	0.002703
MILL RECOVERY - - - - - - - -	0.628614	0.661286	0.649524	0.677616	0.629639	0.663924	0.652939	0.645649	0.651193
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	46.122	45.203	56.792	45.799	51.056	51.193	53.777	47.302	44.468
PRICE/UNIT RECOVERED- - - -	29313.28	27108.98	26378.09	33350.62	28292.34	20960.16	16719.79	28884.02	32515.31
UNITS RECOVERED - - - - - - -	0.	0.	2529.	4458.	4891.	5044.	4775.	4953.	5281.
REVENUES- - - - - - - - - - -	0.	0.	66721248.	148668352.	138383488.	105715072.	79845072.	143057152.	171716272.
DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER									
ORE GRADE - - - - - - - - - -	0.010985	0.010397	0.010095	0.009816	0.010245	0.010459	0.010588	0.010843	0.010792
MILL RECOVERY - - - - - - - -	0.906854	0.915984	0.922451	0.919803	0.910275	0.916051	0.908825	0.917127	0.913725
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SMELTER CONCENTRATE GRADE -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REFINER RECOVERY- - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REFINER- - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TO REFINERY- - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TO MARKET- - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRICE/UNIT RECOVERED- - - -	1614.16	2211.46	2031.20	1598.43	1923.90	1389.19	1565.52	2291.58	1581.97
UNITS RECOVERED - - - - - - -	0.	0.	13968.	22572.	27977.	28742.	28868.	29833.	29582.
REVENUES- - - - - - - - - -	0.	0.	28371904.	36079040.	53825136.	39928512.	45193616.	68365312.	46797248.
DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
NICKEL									
ORE GRADE - - - - - - - - - -	0.013274	0.013785	0.013404	0.013147	0.013256	0.013275	0.012753	0.013540	0.013713
MILL RECOVERY - - - - - - - -	0.923851	0.922284	0.917235	0.922131	0.906576	0.926744	0.931681	0.929250	0.921588
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	54.400	48.816	62.960	54.418	50.103	39.418	38.247	37.039	37.488
PRICE/UNIT RECOVERED- - - -	6635.23	5878.02	5527.47	7069.97	6839.34	8921.17	7231.21	8206.82	6341.33
UNITS RECOVERED - - - - - - -	0.	0.	18441.	30308.	36054.	36907.	35644.	37746.	37915.
REVENUES- - - - - - - - - -	0.	0.	101933728.	214275200.	246582448.	329257728.	257751216.	309778176.	240428272.
DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
MANGANESE									
ORE GRADE - - - - - - - - - -	0.285300	0.276806	0.273395	0.264347	0.253853	0.268456	0.280494	0.263731	0.269005
MILL RECOVERY - - - - - - - -	0.502424	0.461463	0.523726	0.494462	0.415938	0.469209	0.460241	0.467418	0.469461
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	58.305	51.669	43.023	50.912	40.489	51.612	50.051	45.885	56.691
PRICE/UNIT RECOVERED- - - -	520.39	606.33	585.70	476.99	392.56	452.50	569.37	483.44	555.62
UNITS RECOVERED - - - - - - -	0.	0.	214776.	326774.	316762.	377885.	387284.	369818.	378861.
REVENUES- - - - - - - - - -	0.	0.	125794864.	155868816.	124347488.	170993120.	220510000.	178783856.	210504880.

DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
FINANCIAL SUMMARY * * * * * *									
CASH FLOW									
EXPENSED EXPLORATION +									
TOTAL REVENUES- - - - - - - -	0.	0.	349064704.	554891264.	563138304.	645894144.	603299840.	699984384.	669446400.
LESS MINE OPERATING COSTS -	0.	0.	42562768.	84886544.	86061072.	126131088.	99466128.	95306528.	90765552.
LESS TRAN OPERATING COSTS -	0.	0.	11955957.	19433200.	26211664.	24290672.	26092736.	25839360.	30431120.
LESS PROCESS OPERATING COSTS	0.	0.	182892080.	385736704.	425112576.	376034560.	382744064.	365745152.	409581568.
LESS TRANS TO MARKET- - - -	0.	0.	10544947.	18490128.	14881581.	21216448.	21004064.	18601568.	23134144.
LESS EXPLORATION COSTS- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEVELOPMENT COSTS- - -	0.	0.	4550739.	7584567.	9101482.	9101482.	9101482.	9101482.	9101482.
LESS LOAN INT. PAYMENTS - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEPRECIATION - - - - - -	0.	0.	0.	35099552.	66339584.	86213376.	113286336.	135803184.	149766912.
LESS TOTAL ROYALTY PAYMENTS-	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUALS NET INCOME - - - - - -	0.	0.	96558224.	3660800.	-64569344.	2906880.	-48394496.	49587456.	-43334144.
PLUS DEPRECIATION - - - - - -	0.	0.	0.	35099552.	66339584.	86213376.	113286336.	135803184.	149766912.
PLUS TOTAL DEPLETION USED -	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLUS DEFFERED DEDUCTIONS- -	0.	0.	4550739.	7584567.	9101482.	9101482.	9101482.	9101482.	9101482.
LESS EQUITY INVESTMENT- - -	303550208.	252916272.	264025264.	334599936.	0.	0.	0.	0.	0.
EQUALS CASH FLOW- - - - - - -	-303550208.	-252916272.	-162916288.	-288254720.	10871722.	98221728.	73993312.	194492112.	115534240.
ANALYSIS FIGURES									
CONTINUOUS RATE OF RETURN -	0.0	0.0	0.0	0.0	-90.000	-40.000	-40.000	-26.644	-20.252
NOTE - * INDICATES THAT A DUAL RATE OF RETURN EXISTED IN THAT YEAR									
0.10 PCT PRESENT VALUE- -	**								

	19	20	21	22	23	24	25	26	27
GENERAL DATA * * * * * * * * *									
INVESTMENTS									
EXPLORATION - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAND ACQUISITION- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
RESEACH & DEVELOPMENT,- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 1- MINE- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	41382080.	41382080.	41382080.	41382080.	25294096.	19658144.	14282047.	6410361.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 2- TRAN- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	8400618.	8400618.	8400618.	8400618.	5469851.	2611652.	1311783.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 4- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	4449183.	4449183.	4449183.	4449183.	2055571.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 5- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	2180943.	2180943.	2180943.	2180943.	954454.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 6- PROC- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	93354128.	93354128.	93354128.	93354128.	80893408.	61157536.	47959728.	30070224.	13963731.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUITY CAPITAL- - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
WORKING CAPITAL - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPERATING COSTS PER UNIT									
MINE- - - - - - - - - - - - -	29.91309	35.02025	37.15149	35.60149	35.16556	29.76476	27.41251	33.80933	28.63858
TRANSPORT - - - - - - - - - -	8.82858	8.27443	8.71826	9.50596	9.84035	8.50798	8.03441	10.62633	9.68522
PROCESS - - - - - - - - - - -	130.04559	126.70126	138.55661	132.17854	123.87463	127.88161	126.15251	122.08336	154.95735
UNITS TREATED- - - - - - - - -	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.
MISC. OPERATING EXPENSES - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
COMMODITY DATA * * * * * * * *									
COBALT									
ORE GRADE - - - - - - - - -	0.002490	0.002629	0.002478	0.002364	0.002600	0.002327	0.002395	0.002568	0.002634
MILL RECOVERY - - - - - - - -	0.633241	0.630405	0.673835	0.659813	0.664660	0.647420	0.676494	0.654249	0.669397
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	49.042	57.667	33.475	57.098	43.902	55.882	51.875	48.389	52.175
PRICE/UNIT RECOVERED- - - -	21981.09	28849.22	19916.02	35021.25	28129.92	26946.56	20815.14	35299.69	21383.61
UNITS RECOVERED - - - - - -	4730.	4972.	5009.	4680.	5184.	4519.	4860.	5040.	5289.
REVENUES- - - - - - - - - -	103972112.	143442480.	99757984.	163888768.	145825072.	121762880.	101155776.	177918688.	113095504.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

SEVERANCE TAX	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER									
ORE GRADE	0.010590	0.010251	0.010175	0.010752	0.010158	0.010001	0.010612	0.010297	0.010476
MILL RECOVERY	0.913139	0.906702	0.929934	0.916606	0.920561	0.919554	0.910517	0.931338	0.920698
MILL CONCENTRATE GRADE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SMELTER CONCENTRATE GRADE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REFINER RECOVERY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OP. COSTS/UNIT PROCESSED									
SMELTER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REFINER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TO REFINERY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TO MARKET	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRICE/UNIT RECOVERED	1912.46	1388.30	1565.52	1330.62	2468.98	1593.42	2197.16	1571.24	2182.85
UNITS RECOVERED	29010.	27885.	28385.	29565.	28053.	27589.	28986.	28771.	28937.
REVENUES	55481008.	38712608.	44437296.	39339888.	69262656.	43960848.	63686704.	45206576.	63164720.
DEPLETION	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.
NICKEL									
ORE GRADE	0.013681	0.013691	0.013344	0.013398	0.013029	0.013544	0.013552	0.013651	0.012928
MILL RECOVERY	0.922090	0.912754	0.924337	0.923998	0.916963	0.915017	0.923009	0.926100	0.920140
MILL CONCENTRATE GRADE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET	49.415	32.703	52.246	51.372	39.983	59.111	47.667	58.190	57.017
PRICE/UNIT RECOVERED	7970.06	7457.76	8802.79	7216.92	6257.64	8100.68	7696.56	7551.65	8843.61
UNITS RECOVERED	37844.	37489.	37003.	37140.	35841.	37179.	37526.	37927.	35686.
REVENUES	301619968.	279580672.	325731840.	268039264.	224278080.	301178624.	288818432.	286413568.	315596544.
DEPLETION	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.
MANGANESE									
ORE GRADE	0.274980	0.276721	0.265601	0.279845	0.266751	0.267565	0.277695	0.266727	0.265027
MILL RECOVERY	0.534256	0.487939	0.520629	0.523521	0.516828	0.510526	0.510417	0.431006	0.495901
MILL CONCENTRATE GRADE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED									
SMELTER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED									
TO SMELTER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET	47.767	50.034	35.726	45.689	44.274	49.988	48.936	43.309	35.015
PRICE/UNIT RECOVERED	624.37	424.57	367.26	545.74	629.53	425.11	366.29	727.50	419.52
UNITS RECOVERED	440728.	405069.	414838.	439514.	413593.	409797.	425220.	344883.	394281.
REVENUES	275179520.	171980240.	152353824.	239861456.	260369712.	174207904.	155755616.	250902144.	165409520.

DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.	0.	0.

FINANCIAL SUMMARY * * * * * *

CASH FLOW

EXPENSED EXPLORATION +									
TOTAL REVENUES- - - - - - - -	736252416.	633715712.	622280704.	711129088.	699735296.	641110016.	609416192.	760440832.	657265920.
LESS MINE OPERATING COSTS -	89739248.	105060736.	111454464.	106804448.	105496672.	89294256.	82237504.	101427968.	85915728.
LESS TRAN OPERATING COSTS -	26485712.	24823280.	26154784.	28517888.	29521040.	25523936.	24103232.	31878976.	29055664.
LESS PROCESS OPERATING COSTS	390136576.	380103680.	415669760.	396535552.	371623680.	383644672.	378457344.	366249984.	464871936.
LESS TRANS TO MARKET- - - -	23154336.	21779856.	16921456.	22255920.	19972144.	22935248.	22849344.	17387568.	16116482.
LESS EXPLORATION COSTS- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEVELOPMENT COSTS- - -	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.
LESS LOAN INT. PAYMENTS - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
LESS DEPRECIATION - - - - -	149766912.	149766912.	149766912.	149766912.	114667360.	83427328.	63553552.	36480576.	13963731.
LESS TOTAL ROYALTY PAYMENTS-	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUALS NET INCOME - - - - -	47868416.	-56920064.	-106787840.	-1852928.	49353216.	27183360.	29114112.	197914624.	38241280.
PLUS DEPRECIATION - - - - -	149766912.	149766912.	149766912.	149766912.	114667360.	83427328.	63553552.	36480576.	13963731.
PLUS TOTAL DEPLETION USED -	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLUS DEFFERED DEDUCTIONS- -	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.
LESS EQUITY INVESTMENT- - -	0.	0.	0.	0.	0.	0.	0.	0.	0.
EQUALS CASH FLOW- - - - - -	206736800.	101948320.	52080544.	157015456.	173122048.	119712160.	101769136.	243496672.	61306480.

ANALYSIS FIGURES

CONTINUOUS RATE OF RETURN -	-13.211	-10.827	-9.741	-7.059	-4.913	-3.743	-2.891	-1.278	-0.943

NOTE - * INDICATES THAT A DUAL RATE OF RETURN EXISTED IN THAT YEAR

0.10 PCT PRESENT VALUE- -	***********	***********	***********	-899854080.	-730599936.	-613679360.	-514382592.	-277039104.	-217341600.

	28	29	30	31	32	33	34
GENERAL DATA * * * * * * * * *							
INVESTMENTS							
EXPLORATION - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
LAND ACQUISITION- - - - - -	0.	0.	0.	0.	0.	0.	0.
RESEACH & DEVELOPMENT,- - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 1- MINE- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 2- TRAN- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 4- PROC- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 5- PROC- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
INVEST. NUMBER 6- PROC- - -	0.	0.	0.	0.	0.	0.	0.
LIFE - - - - - - - - - -	0	0	0	0	0	0	0
DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
SALVAGE VALUE- - - - - -	0.	0.	0.	0.	0.	0.	0.
EQUITY CAPITAL- - - - - - -	0.	0.	0.	0.	0.	0.	0.
WORKING CAPITAL - - - - - -	0.	0.	0.	0.	0.	0.	0.
OPERATING COSTS PER UNIT							
MINE- - - - - - - - - - - - -	27.20061	46.11247	35.96475	32.93745	29.11087	28.89999	3.33000
TRANSPORT - - - - - - - - - -	8.87856	8.63639	8.18825	9.39910	8.31666	8.80445	0.80000
PROCESS - - - - - - - - - - -	141.62140	133.37959	130.52190	147.50250	128.26472	123.07216	11.80000
UNITS TREATED- - - - - - - - -	3000000.	3000000.	3000000.	3000000.	3000000.	3000000.	1500000.
MISC. OPERATING EXPENSES - - -	0.	0.	0.	0.	0.	0.	0.
COMMODITY DATA * * * * * * * *							
COBALT							
ORE GRADE - - - - - - - - -	0.002499	0.002642	0.002575	0.002599	0.002537	0.002499	0.002676
MILL RECOVERY - - - - - - -	0.640401	0.669669	0.638139	0.652465	0.658097	0.678895	0.634016
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED							
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED							
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	55.225	53.975	55.545	60.935	36.467	46.770	49.484
PRICE/UNIT RECOVERED- - - -	34371.56	24962.70	29614.92	27387.42	26343.28	23355.88	30102.19
UNITS RECOVERED - - - - - -	4802.	5308.	4929.	5087.	5009.	5089.	2545.
REVENUES- - - - - - - - - -	165038400.	132513296.	145970432.	139311040.	131956672.	118863712.	76603424.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.

SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.
COPPER							
ORE GRADE - - - - - - - - -	0.010184	0.010224	0.010386	0.010676	0.010753	0.010427	0.009775
MILL RECOVERY - - - - - - -	0.924721	0.911830	0.908702	0.928321	0.920724	0.919412	0.920950
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SMELTER CONCENTRATE GRADE -	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REFINER RECOVERY- - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OP. COSTS/UNIT PROCESSED							
SMELTER- - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REFINER- - - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRANS. COSTS/UNIT PROCESSED							
TO SMELTER - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TO REFINERY- - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TO MARKET- - - - - - - -	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRICE/UNIT RECOVERED- - - -	2032.63	1465.37	1548.35	2297.30	1444.81	1555.51	1929.62
UNITS RECOVERED - - - - - -	28251.	27966.	28315.	29732.	29703.	28761.	13503.
REVENUES- - - - - - - - - -	57424352.	40981168.	43841024.	68304336.	42914576.	44737856.	26056336.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.
NICKEL							
ORE GRADE - - - - - - - - -	0.013703	0.012763	0.013108	0.013162	0.012890	0.013008	0.013944
MILL RECOVERY - - - - - - -	0.926321	0.923701	0.908243	0.924514	0.904636	0.928304	0.918310
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED							
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED							
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	54.920	52.731	45.583	44.502	40.392	56.162	46.514
PRICE/UNIT RECOVERED- - - -	6606.66	9019.14	8521.13	7843.52	8549.71	6700.55	9035.47
UNITS RECOVERED - - - - - -	38080.	35367.	35715.	36504.	34982.	36227.	19207.
REVENUES- - - - - - - - - -	251580528.	318982144.	304332544.	286322176.	299082240.	242738528.	173544064.
DEPLETION - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - -	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - -	0.	0.	0.	0.	0.	0.	0.
MANGANESE							
ORE GRADE - - - - - - - - -	0.276396	0.269883	0.264378	0.280189	0.273951	0.271206	0.264381
MILL RECOVERY - - - - - - -	0.476607	0.514304	0.410227	0.540550	0.468928	0.487718	0.550905
MILL CONCENTRATE GRADE- - -	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SMELTER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
SMELTER CONCENTRATE GRADE -	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REFINER RECOVERY- - - - - -	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
OP. COSTS/UNIT PROCESSED							
SMELTER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REFINER- - - - - - - - -	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TRANS. COSTS/UNIT PROCESSED							
TO SMELTER - - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO REFINERY- - - - - - -	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TO MARKET- - - - - - - -	50.420	48.149	50.501	45.538	49.066	48.272	41.738
PRICE/UNIT RECOVERED- - - -	459.59	566.80	619.22	518.46	414.58	359.37	730.94
UNITS RECOVERED - - - - - -	395197.	416406.	325366.	454369.	385390.	396816.	218473.
REVENUES- - - - - - - - - -	181628512.	236017584.	201472640.	235570768.	159774976.	142601824.	159690416.

104

DEPLETION - - - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
SEVERANCE TAX - - - - - - - -	0.	0.	0.	0.	0.	0.	0.
ROYALTY PAYMENT - - - - - - -	0.	0.	0.	0.	0.	0.	0.

FINANCIAL SUMMARY * * * * * *

CASH FLOW

EXPENSED EXPLORATION +							
TOTAL REVENUES- - - - - - - -	655671552.	728493824.	695616512.	729508096.	633728256.	548941824.	435894016.
LESS MINE OPERATING COSTS -	81601808.	138337408.	107894256.	98812352.	87332608.	86699968.	4994999.
LESS TRAN OPERATING COSTS -	26635680.	25909168.	24564736.	28197296.	24949968.	26413328.	1200000.
LESS PROCESS OPERATING COSTS	424864000.	400138752.	391565568.	442507264.	384794112.	369216256.	17700000.
LESS TRANS TO MARKET- - - -	22282352.	22200896.	18333072.	22625504.	20505328.	21427664.	10137865.
LESS EXPLORATION COSTS- - -	0.	0.	0.	0.	0.	0.	0.
LESS DEVELOPMENT COSTS- - -	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.	4550739.
LESS LOAN INT. PAYMENTS - -	0.	0.	0.	0.	0.	0.	0.
LESS DEPRECIATION - - - - - -	0.	0.	0.	0.	0.	0.	0.
LESS TOTAL ROYALTY PAYMENTS-	0.	0.	0.	0.	0.	0.	0.
EQUALS NET INCOME - - - - -	91186432.	132806400.	144157696.	128264448.	107045120.	36083456.	397310208.
PLUS DEPRECIATION - - - - -	0.	0.	0.	0.	0.	0.	0.
PLUS TOTAL DEPLETION USED -	0.	0.	0.	0.	0.	0.	0.
PLUS DEFFERED DEDUCTIONS- -	9101482.	9101482.	9101482.	9101482.	9101482.	9101482.	4550739.
LESS EQUITY INVESTMENT- - -	0.	0.	0.	0.	0.	0.	0.
EQUALS CASH FLOW- - - - - -	100287904.	141907872.	153259168.	137365920.	116146592.	45184928.	401860864.

ANALYSIS FIGURES

CONTINUOUS RATE OF RETURN -	-0.442	0.176	0.744	1.183	1.511	1.629	2.497
NOTE - * INDICATES THAT A DUAL RATE OF RETURN EXISTED IN THAT YEAR							
0.10 PCT PRESENT VALUE- -	-119783392.	18124016.	166913824.	300140544.	412674560.	456410368.	844994560.

105

SUMMARY DATA

ENTERPRISE EVALUATION SIMLTN. 3M.TONNES NODULES(DRY)P.A. [CUPRION PROCESS]

	LAST YEAR ADDITIONS TO CASH FLOW
CUMULATIVE WORKING CAPITAL	334599936.
CUMULATIVE SALVAGE VALUE	0.
	OTHER CUMULATIVE VALUES
REVENUES	14558650400.
ROYALTIES	0.
TOTAL DEPRECIATION	1497668610.
FEDERAL INCOME TAXES	0.
CASH FLOW	896540416.
	LAST YEARS ANALYSIS FIGURES
CONTINUOUS RATE OF RETURN	2.497
0.10 PCT PRESENT VALUE	844994560.

COMMODITY SUMMARY DATA

COMMODITY	REVENUES	UNITS RECOVERED	PRICE/UNIT
COBALT	2935180800.	108982.	26378.086
COPPER	1106071040.	624954.	2031.201
NICKEL	6167830530.	802732.	5527.469
MANGANESE	4349575170.	8652092.	585.703

TOTAL INITIAL INVESTMENT DATA

ITEM	AMOUNT
EXPLORATION	26243232.
LAND ACQUISITION	0.
RESEARCH & DEVELOPMENT	198715760.
MINE AND TRANS SHIPS	497826816.
PROCESS PLANT AND PORT	999842048.
WORKING CAPITAL	334599936.
MISC INVEST & OP COSTS	0.
TOTAL UNITS TREATED	65500000.

EXPECTED DISTRIBUTION FOR PCT RATE OF RETURN
CURVE REPRESENTS THE PROBABILITY THE LISTED VALUE HAS OF OCCURRING BASED ON 150 SIMULATIONS

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 PCT RATE OF        PERCENT
   RETURN         OCCURRENCE

     -1               2.7  ***
      0               5.3  *****
      1              26.0  **************************
      2              38.7  ***************************************
      3              25.3  *************************
      4               2.0  **
```

MEAN PCT RATE OF RETURN = 1.88

ROR RESULTS FOR EACH SIMULATION

2.497	2.565	2.661	3.542	2.016	2.302	1.587	-0.809
2.156	0.406	2.104	1.300	2.983	2.353	2.416	3.265
1.425	2.577	1.735	2.718	1.334	2.982	2.551	3.209
1.056	3.265	0.696	1.675	1.749	2.063	2.752	1.932
2.417	1.313	2.954	2.334	1.104	2.680	1.920	1.635
0.950	1.212	2.086	1.772	2.401	2.520	3.118	2.146
1.491	0.660	2.968	1.615	3.196	1.988	0.540	3.109
0.818	2.398	2.229	2.966	2.792	1.267	1.678	1.971
0.394	0.574	2.158	1.309	0.476	3.164	2.802	1.110
2.531	2.103	1.827	3.106	2.715	0.534	2.019	3.425
0.011	0.951	2.957	1.709	1.823	2.488	1.528	0.066
1.068	-0.580	2.053	2.663	2.053	1.993	2.400	2.405
1.420	1.155	-0.556	3.891	2.950	2.804	2.533	1.192
2.389	1.229	2.219	1.402	1.337	2.024	1.071	2.668
3.157	2.222	1.370	2.535	2.351	3.002	1.607	0.561
0.912	2.858	-0.655	1.932	2.251	0.811	0.223	1.989
2.917	2.267	0.987	2.101	-0.004	1.329	1.500	0.582
3.641	1.795	2.362	1.887	1.732	1.903	1.175	0.117
2.432	1.191	1.432	2.365	2.656	1.411		