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# SMALL-SCALE GOLD MINING IN INDONESIA

by

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# ABSTRACT

The geological setting of the Indonesian island arcs, situated at the convergence of three lithospheric plates and largely covered by tertiery volcanic rocks, is the most promising area for epithermal gold deposits. Recent exploration results show positive indications of widespread occurrences that can be exploited by the appropriate mining operation.

Small-scale gold mining, which involves management and utilization of mineral resources, can be an important base for the economic development of Indonesia. The mines are a promising source of national income and foreign exchange and at the same time could provide a starting point for the opening up and development of the region. This thesis constructs an economic model and applies it to three hypothetical projects. The results indicate that small-scale gold mining operations can be very profitable under certain economic and technical situations.

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# Chapter 1

# INTRODUCTION

The Republic of Indonesia is an island archipelago straddling the equator off the coast of the southeast Asian land mass. Made up of 13,500 islands of which only about 3,000 are inhabited, Indonesia has a total land area of about 2 million square kilometers with maximum dimensions of 5,500 km from east to west and 1,600 km from north to south (see Figure 1.1). The country is tropical, and although much of the land is under intensive cultivation, large parts are sparsely populated and heavily forested. Indonesia is one of the most populated countries of the world, 175 million, ranking fifth after China, India, the USSR, and the United States. About 60% of the people live on the Java and Madura islands, leaving vast stretches, particularly in Kalimantan and Irian Jaya islands, sparsely populated.

The minerals sector has played an important role in Indonesia's economy, initially as a source of export earnings, but to a growing extent as a source of employment and future development.

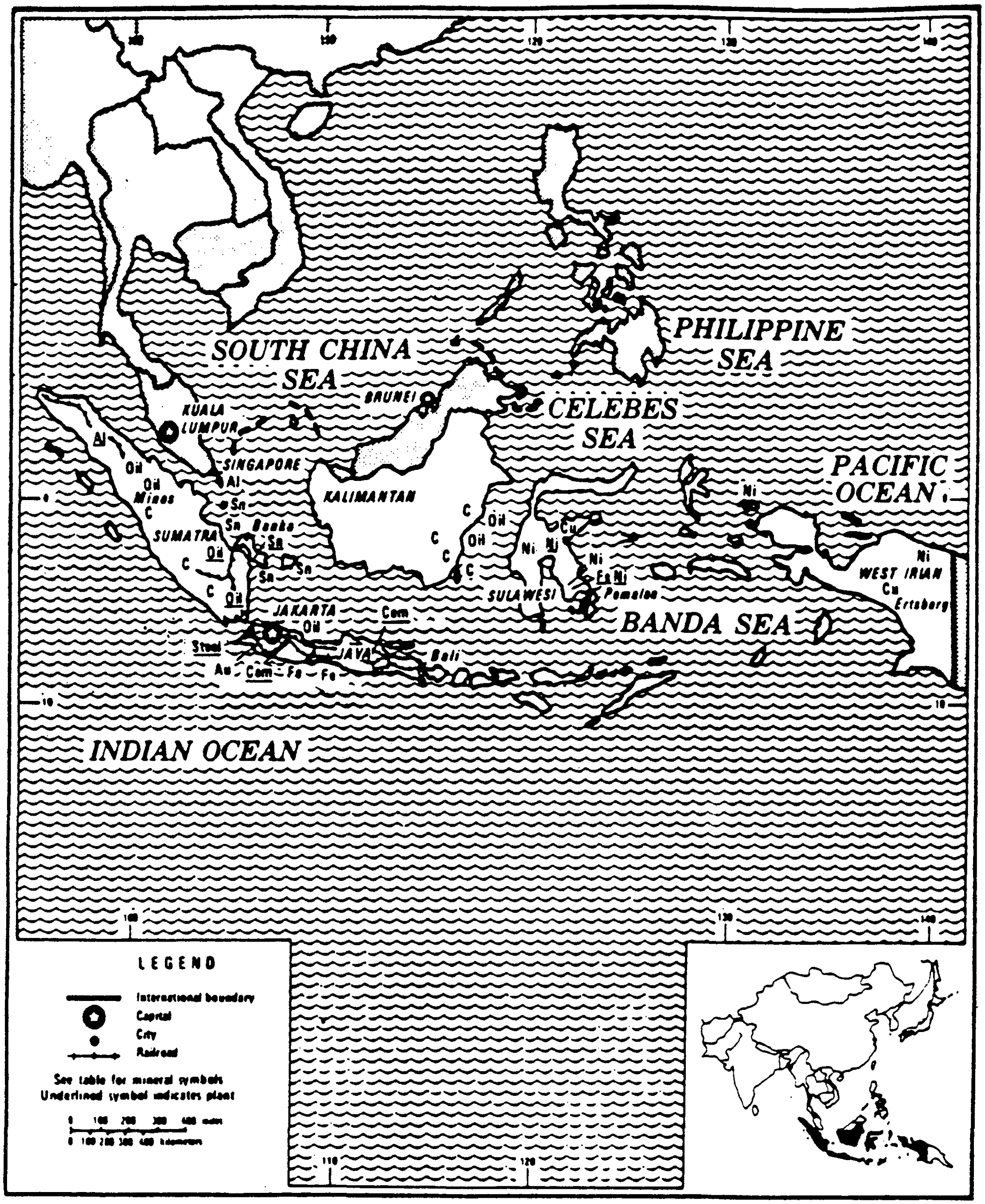


Figure 1.1. Map of Indonesia

Source: U.S. Bureau of Mines, 1977, <u>Mineral Perspectives</u>, MP-1, <u>Far East and South Asia</u>, Washington, D.C: GPO.

The mineral industry continues to contribute about 20% to Indonesia's GDP. Its exports accounted for 60% of earnings in 1987 (Wu, 1987). The oil and gas industry is still the leading mineral sector, followed by the tin industry.

In 1987, the United States, the European Economic Community (EEC), South Korea, and Singapore, based on the value of two-way trade, were Indonesia's major trading partners. Most of Indonesia's mineral production went to those countries and they, in turn, remained as the principal suppliers of Indonesia's capital goods, electrical equipment, machinery, and chemicals.

Following the collapse of oil prices in the international market, a significant effort was made to increase mineral development. Relatively higher gold prices pushed investments in the gold mining industry, with most explorationt carried out by a number of relatively small mining operations. The Department of Mines and Energy reported that since 1987 more than one hundred Contracts of Work have been signed between the state and gold mining companies. On the basis of Contract of Work agreements with the government, companies obtain exclusive rights to conduct exploration and development of gold deposits in Indonesia.

Those companies are encouraged to go into joint ventures with small holders of mining authorizations or mining rights.

## 1.1. Purpose and Scope

The purpose of this study is to evaluate the economic viability of small-scale gold mining in Indonesia as an appropriate type of operation. The scope of this thesis is limited to an economic evaluation of a small-scale gold mining operation in Central Kalimantan.

An economic model of a small-scale operation was developed that combines standard cash flow and rate of return analysis with several risk analyses. By understanding the factors that can affect the operation of small mine, the strengths and weaknesses of small-scale mining operations can be evaluated.

## 1.2. Definition

In spite of the frequent use of scale concepts to describe the size of mining operations, a universally accepted consensus regarding the definition of the terms "small-scale" and "medium-scale" in quantitative units does not exist. However, small is a relative term. Even though many authors have referred to the small mining operation, there exists no common definition. It is attributable to the fact that a number of factors can basically be employed for demarcation purposes, each apparently particularly suitable in a specific situation.

Some of the circumstances under which a mine can be considered small are the following: it is operated by an individual, partnership, or corporation which is not listed on a major stock exchange; it annually produces less than 200,000 tons of coal, industrial minerals or sedimentary materials requiring further processing; or it annually mines or extracts less than 50,000 tons of igneous or metamorphic rock requiring mineral benefication (Delfour and Rees, 1977). The U.S. Bureau of Mines classifies the small-scale mine as one that produces up to 360 tons per day, with a total employment up to 50 persons (Wiebmer, 1979).

By international standards, a small mine is any single unit mining operation with an annual production of 50,000 metric tons or less (Meyer, 1978). As shown in Table 1.1, the definition of small-scale mining varies widely, usually depending on the country's degree of industrialization. Generally, definitions are based on one or more of the following criteria which exhibit distinct variances as a result of the scale of operation as indicated:

Table 1.1. Criteria for Determining Size of Mine Operations

| Criterion | Small-scale | Large-scale |
|---|---|---|
| Mine output ton per year | small | large |
| Number of employed | large | small |
| Gross annual income | low | high |
| Degree of mechanization | low | high |
| Labor productivity | low | high |
| Size of mining concession | small | large |
| Size of reserve | small/unknown | large/well-known |

Source: Noetstaller, R. 1987. Small-Scale Mining. World Bank Technical Paper No. 75. Washington, D.C.

Mine output is the only broadly applicable and universally acceptable criterion in the mining industry. The number of persons employed varies greatly depending on the type of operation and the geological features of the deposit and the mining technology used.

Gross annual income largely depends on the unit value of the commodity. The size of the mining lease required to permit a desired scale of operation is influenced by geological characteristics, such as the shape and type of the mineralization. The size of the reserve is dependent upon ore grade. Table 1.2 lists Asian countries and the ore produced from their small-scale mining operations.

Table 1.2. Small-scale Mining Operations in Asian Countries

| Country | Mineral Commodity |
| --- | --- |
| Burma | Antimony, manganese, tin, tungsten |
| China | Tin, antimony, tungsten, iron, coal |
| India | Barite, borax, iron, manganese, mica, tin, coal |
| Indonesia | Tin, gold |
| Iran | Barite, copper, lead, zinc |
| Malaysia | Gold, iron, manganese, tin, tungsten, zinc |
| Philippines | Chromium, copper, gold, silver, zinc, coal |
| Thailand | Antimony, tin, tungsten |
| Turkey | Chromite, copper, lead, magnesite, mercury |

Source: Noetstaller, R. 1987. Small-Scale Mining World Bank Technical Paper No. 75. Washington D.C.

Traditionally, small-scale mining has played an important role in the development of many nation's mineral resources by substantially contributing to new discoveries and permitting the exploitation of limited deposits. Under favorable circumstances, small-scale mining has the potential of contributing significantly to employment and economic progress.

# Chapter 2

# INDONESIA'S GOLD MINING INDUSTRY

## 2.1. Historical Background

Gold mines have been worked in Indonesia since before recorded history. There is evidence of ancient workings in North and Central Sumatra, but little recent action until the late nineteenth and twentieth centuries. Of some 13 gold silver bearing zones identified in West Sumatra, two mines at Lebong Denok and Lebong Tandai were developed between 1910 and 1940. The gold at Cikotok in South Banten, Java, was discovered in 1926 and production was started in 1936. In addition, a number of small gold dredges were introduced into Sumatra to work in areas which had long been mined by the local population.

In 1939, total gold production was some 2.5 tons, about half of which was produced from Lebong Tandai. The search for other minerals was stepped up gradually in the early years of this century both by the state and the private companies.

By the end of the Dutch rule in 1942, three major mining activities had taken place:

1. Mining operations were established for oil, tin, gold, coal, and bauxite, run either by the state or private companies.
2. The Bureau of Mines was established, and a mining code put in place to regulate mining rights and mining activities. Experts from the Bureau of Mines were also active in mapping and in the publication of the results of this work.
3. Many Dutch geologists of the Dutch period contributed a great deal to the study and understanding of the geology and mineral wealth of Indonesia.

The basic information and geological data accumulated during this period still serves as the basis for exploration in Indonesia.

During World War II, Japan occupied Indonesia between 1942 and 1945. Many of the mines were flooded or damaged to prevent their use by the Japanese, but during this period active steps were taken by the Japanese to rehabitate them, and production of tin and coal was resumed on a limited basis. A number of new developments were started to supply the Japanese war effort, including small cement plants.

The period of occupation, however, was too short for any important developments. The economy was seriously disrupted during the three and half years of Japanese occupation. Even more damage was inflicted on the existing infrastructure and vital plants after the occupation ended due to the scorched earth policy of the freedom fighters.

Indonesia declared its independence on 17 August 1945. The declaration was followed by four and a half years of armed struggle against the Netherlands which was trying to reestablish its rule. With the worsening of the relationship between the Netherlands and Indonesia and the severing of diplomatic relations between the two countries, Indonesia in 1957 proclaimed the nationalization of all Dutch property in the country, including the existing Dutch-owned private mining companies. However, production of ores, such as tin, gold, coal, and silver declined rapidly as a result of economic conditions and the unavailability of foreign exchange to import replacement equipment and spare parts.

The year 1966 signaled the start of the so-called "New Order" government that has provided political stability and allowed the country to embark on economic development. Indonesia has successfully carried out three 5-year plans

(1969-1984) with relatively high growth, and now is well into the fourth 5-year plan, with rather low growth caused by recession. Targets of these economic plans are to increase nonoil exports and to get domestic industry growing and competitive.

During the last decade the government structure for promoting and monitoring mineral development has evolved in a positive way, as is borne out by the significant increase in foreign investment in the mineral industry. Indonesia's unexplored mineral potential began to attract the attention of the world mining community beginning in 1967 when multinational companies started coming in.

## 2.2. Indonesian Gold Deposits

The tectonic framework of Indonesia is complicated owing to the interaction of the Eurasian, the Indian-Australian, and the Pacific plates. Katili (1974), explains how the tectonic theory has been largely applied in mineral exploration following the postulations put forward by others. The convergent plate boundaries along continental margins and island arcs are potential areas for epithermal gold deposition.

Gold occurs widely throughout Indonesian island arcs both as lode and alluvial deposits. Indonesia, with many old and present subduction zones and sub-aerial calc-alkaline volcanic rocks, is a promising country for epithermal gold mineralization. Sunarya (1989) reported that characteristics of gold deposits and its occurrences in Indonesia can be divided into epithermal gold deposits, porphyry copper associated gold deposits, and alluvial gold deposits.

2.2.1. <u>Epithermal Gold Deposits</u>

In Sumatra Island, epithermal gold deposits can be found in the west, namely Mangani and Lebong Tandai in Bengkulu. The epithermal gold of Mangani occurs in quartz-rhodochrosite-rhodonite-Ag-Au veins, hosted by tertiary pyroxene andesite volcanic and quartz phyllite conglomerate. Precious metal vein mineralization is characterized by a high Ag/Au ratio (>25), with low total sulphide content of alteration system (Kavalieris, et al. 1987).

The epithermal gold deposits in Lebong Tandai, Bengkulu are hosted by andesitic volcano-clastic and tuffaceous sediment of probably the middle to late Tertiary age. This deposit belongs to the epithermal quartz-lode type which is accompanied by gold, minor sulphides, sulphosalts and tellurides (Alapan, 1987).

Several new discoveries of epithermal gold deposits have been found also in Kalimantan Island which hosted by tertiery volcanics, namely the Kelian deposits which consist of Muyup, Kelian, Mt. Muso, and Masuparia mineralizations. Hawke, et al. (1988), say that these deposits are one of a number of tertiery volcanic-hosted gold deposits developed within a 200 km long by 30 km wide area in a northeast trending volcanic corridor extending from Central Kalimantan to East Kalimantan.

Mt. Muso mineralization occurs in shear zones ranging in width from 1 to 5 meters and up to 6 km long. Veins may consist of stockworks breccias, branching veinlets, and massive veins of intense silification associated with argillic alteration and varying halo propyllitization. Pyrite, galena, sphalerite, chalcopyrite, and arsenopyrite occur with gold below the oxidixed zone, and high silver values are common. It is also reported that the Kelian gold deposits show mineral assemblages typical of quartz-sericite-adularia epithermal gold deposits.

The Muyup epithermal gold mineralization is hosted by andesitic to trachytic fragmental and porphyritic volcanic rocks. Mineralization occurs in disseminated clusters associated with 1%-5% sulphides deposited together with quartz and adularia, illite, chlorite, and carbonate gangue. In Masuparia, Central Kalimantan, epithermal gold type mineralization occurs as quartz veins and stockwork hosted by lower tertiery volcanic and sub-volcanic rocks which have visible gold near the surface level and base metals at deeper level.

In Banda Islands, Maluku, epithermal gold deposits have been discovered hosted by silicified argillized andesite. In Flores, Wetar, and Lomblen islands of Nusatenggara, several new discoveries of epithermal gold type deposits have been reported, hosted by submarine volcanic rocks of the Tertiary age. The Wetar ore deposits are said to be a baryte ore gold deposit (Kuoda, et al. 1988).

The discovery of mineralization in Lomblen island is based on the remotely sensed data that show the ring structure that suggests the cauldron or dome. Kuoda, et al. (1988), suggest that since the island is covered by Neogene to Quarternary volcanic products, gold mineralizations along the other ring structures in the island are quite likely.

Low-grade disseminated gold mineralization has also been discovered in the G. Pani volcanic complex of north Sulawesi. It is also associated with porphyritic rhyolites, interpreted to comprise part of the endogenic volcanic zone assemblage, within 3.5 km volcanic diameter center. Gold mineralization occurs as electrum (20% Ag) with pyrite and in minor base metal sulphides in quartz-adularia lined vugy fractures and brecciated zones.

In 1988, Manurung, et al., as described by Sunarya (1989, which see) issued the reconfirmation of the old known epithermal gold mineralization of the Ratatotok area in northern Sulawesi hosted by Miocene limestone and by early to middle Miocene volcanic formations. The rest of previously known epithermal gold lode deposits of Indonesia have a gold grade of almost above 6 grams/ton and were processed by cyanidation and flotation (Sunarya and Bache, 1987).

### 2.2.2. Porphyry Copper Associated Gold Deposits

The upper Tertiary porphyry Cu/Au deposits were discovered in the Kaputusan area, Bacan island, in north Maluku. About 80% of the mineralization is hosted by the intrusive rocks of the younger tonalite porphyrite, and the remainder occurs in volcanic rocks near the contact. Katili (1988) as described by Sunarya (1989), which see, considers that all aspects of the geological configuration on the northern Maluku island are indicative of the occurrences of epithermal precious metals.

Another new discovery of gold potential was found in Sangihe Island in northern Sulawesi in 1987. It was a network quartz vein containing gold hosted by volcanic rocks as the evidence of the gold mineralization (Satria, et al. 1989).

In Gunung Bijih (Erstberg), Irian Jaya Island, the ore was found with a polymetallic mineralogical association. It was formed in the limestone of the Triassic-Jurassic Kembelangan Formation which was intruded by Pleistocene granodiorite.

### 2.2.3. Alluvial Gold Deposits

Several known alluvial deposits which were developed are Meulaboh, Logas, Sumatra island. In Kalimantan Island, alluvial gold is found in Melawi, Kahayan, Mahakam, and Banjarmasin. Previously, most of these areas were exploited by local miners.

Some new alluvial gold deposits have also been discovered in Nias Island, West Sumatra, and Kasongan in Central Kalimantan. Figure 2.1 shows gold locations in Indonesia. From the available data it might be concluded that more than 50% of the companies holding Contract of Works achieved positive results with average grades mostly below three grams per ton and only some about ten grams per ton. The economic data are not available because most of these activities are still in the exploration stages.

## 2.3. Indonesian Gold Production

Historically, gold production in Indonesia began in the fourth century with the evidence of Chinese alluvial mining in Kalimantan and underground mining in northern and western Sumatra. Many ancient shafts and tunnels have been found which attest to the skills and fortitude of the early miner. During the late nineteenth and twentieth centuries there was a surge in interest in gold in Indonesia and a number of mines were developed, notably at Lebong Tandai and Lebong Donok in Sumatra. With the establishment of the gold price at $35/oz by the U.S government in 1934, gold mining became very attractive.

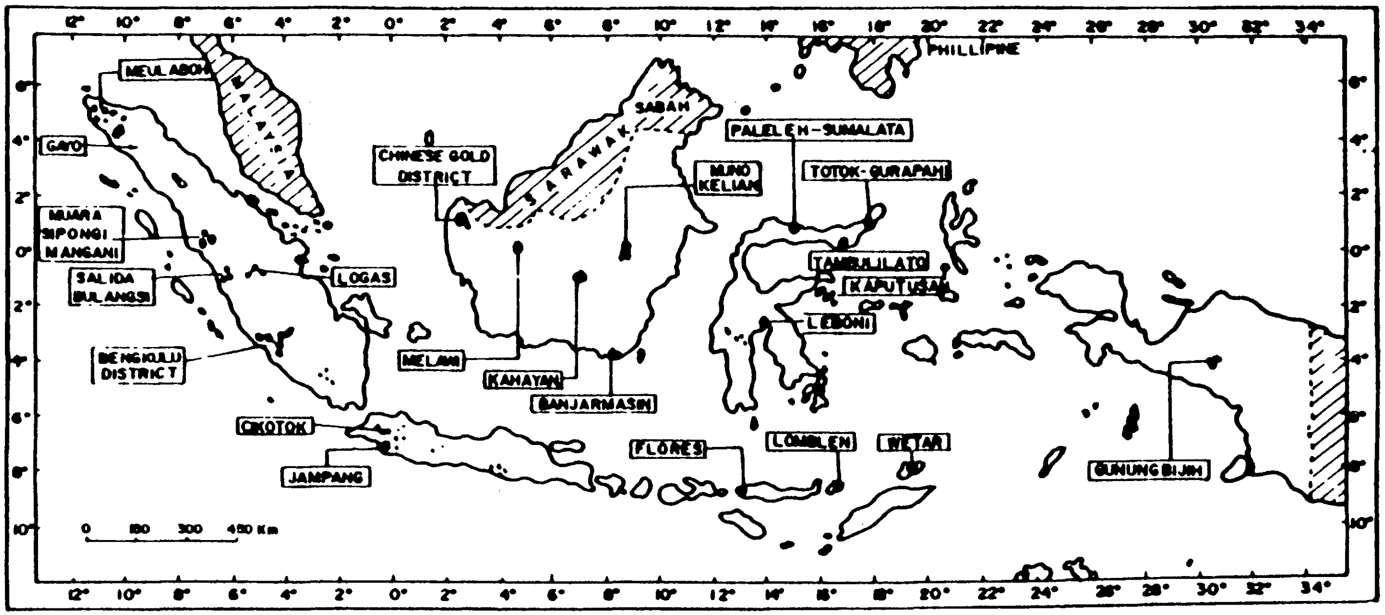


Figure 2.1. Prospective Gold Locations in Indonesia
Source: Journal of the Indonesian Association of Geologists, July 1989.

In addition, a number of quartz dikes containing gold and silver were developed in southwest Java. Based on this, the deposits at Cikotok and Cipicung were developed and production was started in 1936. The gold ore is mined from gold and silver-bearing quartz veins which intersect the andesite masses of the Cikotok and Cirotan mining area almost vertically with a strike in a north-south direction. Actual mining of the deep mine at Cikotok by NV Mijnbouw Maatschappij Zuid Bantam started in 1936 under provision of the 5A contract arrangement. In 1939, the Pasir Gombong cyanide leach processing plant was established. During the Japanese occupation, the mine was run by Mitsui Kosha Kabushiki Keisha with the aim of extracting lead metal from the Cirotan mine in West Java.

In 1961, three different Badan Pimpinan Umum or managing boards were established respectively for tin, coal, and general mining. The three Badan Pimpinan Umum administratively controlled the several state-owned mining company operations at mining sites, such as PN. Timah Bangka, PN. Tambang Batubara Bukit Asam, and PN. Tambang Batubara Ombilin. Based on Governmental Decree No. 19, dated 1960, the State Enterprise P.N. Tambang Mas Cikotok was established in 1961 and came under supervision of B.P.U Pertambangan Umum Negara. With the reorganization in 1968, the three BPUs were dismantled and the several mining activities were managed by the state mining enterprises, including PN. Tambang Batubara (coal), PN. Tambang Timah (tin), and PN. Aneka Tambang (others). Accordingly, PN. Tambang Mas Cikotok became a production unit of P.N. Aneka Tambang. The importance of Cikotok is not in how much gold it produces but that it houses the only cyanide leaching plant in Indonesia.

Presently, there are three official sources of gold and silver production.

1. The state-owned Cikotok Gold Mine in West Java
2. Freeport Indonesia in Irian, where gold is produced as a byproduct of copper
3. P.T. Lusang Mining, which has produced gold since 1986

Indonesia produces about 20 tons of gold annually, although only registered mine production of 3.6 tons was officially recorded in 1987. Latest Department of Mines and Energy reports indicate that gold production was 2,619 kg for 1985 and 3,304 kg for 1986. Production for 1987 was likely closer to 20 tons, considering that the efforts of about 150,000 indigenous and illegal miners are not included in official production figures (see Figure 2.2). In this regard the government has made a clear distinction between "people's mining" and "illegal mining." "People's mining" activities are defined as small-scale mining activities carried out manually by local people using simple tools, and "illegal mining" activities refer to those mining activities carried out by people who come from other parts of the country and use modern equipment such as diesel engines, pumps, and modern processing equipment for recovery of the gold. It is difficult to assess the extent of this production since no official records are kept.

Indonesia's principal gold producer remains Freeport Indonesia in Irian Jaya island, operating a large open pit and underground copper mine at Tembaga Pura. In 1987, Freeport produced 2,958 kg of gold concentrate. P.T. Aneka Tambang, the state-owned mining company, operates the Ciko-tok Mine in West Java, old mines that have long been in decline. Cikotok produced only 515 kg of gold in 1987.

P.T. Lusang Mining was the first of the many Contract of Work arrangements to go into production in late 1985. It

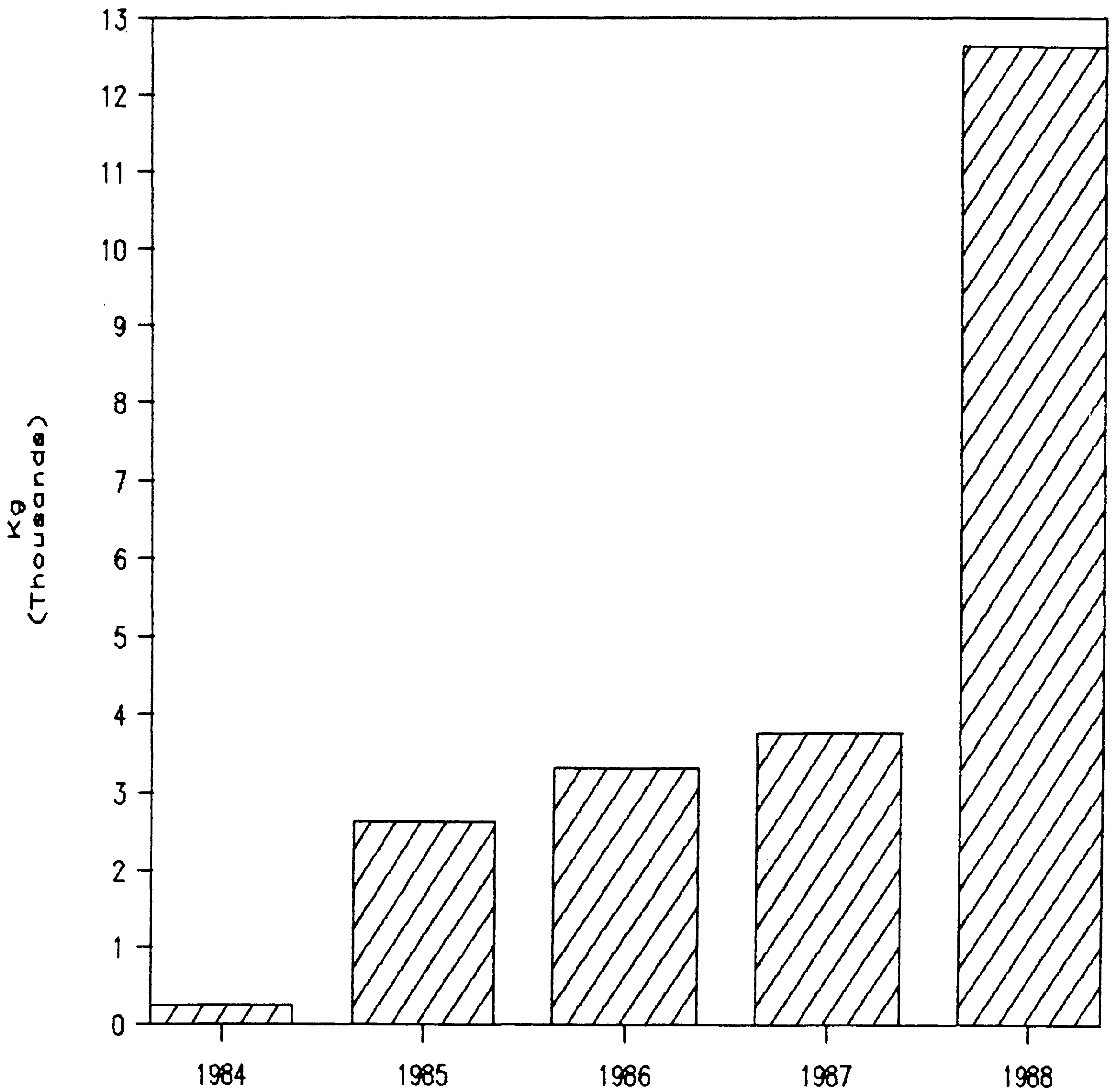


Figure 2.2. Indonesian Gold Production
Source: Ministry of Mines and Energy
Note: Production in 1984 is gold and silver from PT. Aneka Tambang only.

reopened the former Dutch underground mine at Lebong Tandai, in north Bengkulu, Sumatra. Currently, the annual production of the Lusang Mining Company is about 28,000 ounces of gold and 140,000 ounces of silver.

## 2.4. Mineral Policy

The fundamental difference in mineral resources policy between developing countries and most industrial countries is that industrial countries argue that resource management, as distinguished from policy setting, is best left to the private sector. However, it is a fact that for many developing countries like Indonesia, developmment of mineral resources is intimately related to socio-economic and political issues.

Article No. 33 of the 1945 Constitution of Indonesia explicitly states that the land and water and the natural wealth contained therein shall be controlled by the state and used for the maximum prosperity of the people. This implies that there are certain political and ideological constraints imposed on every involvement in mineral resources development. Obviously, a productive solution must be found to accommodate the ideological and political limitations and, at the same time, to fulfill development needs and financial requirements.

In considering the contractual arrangement between government and every participant in the development of hard minerals, the Department of Mines and Energy has established the "Fourth Generation of the Contract of Work" applicable to mining investors for carrying out specific tasks. Minerals are divided into three groups based upon the historic role, present and future potential, and the possible economic importance of each mineral to the state and people. The present grouping is as follows:

2.4.1. Strategic Minerals: oil, asphalt, wax, natural gas, coal, uranium, radium, thorium, nickel, cobalt, and other radioactive minerals.

2.4.2. Vital Minerals: gold, iron, manganese, lead, zircon, vanadium, titanium, zinc, copper, silver, mercury, platinum, bauxite, tungsten, chromium, barite, diamond, and other rare minerals.

2.4.3. Other Minerals: nitrate, phosphate, talc, basalt, asbestos, mica, graphite, granite, magnesite, kaolin, andesite, trachite, lusite, and sandstone.

According to the laws, the mining of strategic minerals can only be undertaken by a government agency appointed by the Minister of Mines and Energy. However, for economic and practical reasons, and in the interest of the development of the region concerned, the minister can designate certain deposits of strategic minerals of limited extent for mining by the private sector or cooperatives. The mining of vital minerals and other minerals can be undertaken by the state, private bodies, or corporations qualified to carry out the project.

In compliance with the Indonesian constitution, high priority is given to achieving a more equitable distribution of development, continued economic growth at a sufficiently high level, and maintenance of national stability. The mineral sector is a source of national income and foreign exchange and must at the same time provide a starting point for the opening up and development of the region and lay the foundation for industrialization.

The mineral policy on hard minerals in relation to private investments as expressed in the Fourth Generation of Contracts which is a modification of the First, Second, and Third Generation of Contracts, is to retain a degree of participation that has to grow with the advancement of national capabilities. This arrangement creates a Contract of Work which means that the private company is only a contractor to the state, surveying and exploring natural resources for and on behalf of the state.

During the development process, the state still holds the property rights and only at the point of export or sale are these rights transmitted to the contractors. Working as the contractor, a foreign or joint venture company will obtain a firm guarantee to carry out the whole mining activity without having to negotiate or to apply for additional mining rights.

Provision is also made for depreciation allowance based on a declining balance sheet method. It stipulates that exemption is granted to the investor from import and other custom duties. Auxiliary supplies needed may be reexported or sold in Indonesia after compliance with import laws and regulations. A paramount feature of this policy is that the terms and conditions in the Contract of Work will not be affected by future changes in the general rules and regulations. Such changes may lead to the drafting of a new generation of contract, but the Department of Mines and

Energy, on behalf of the state, has guaranteed that no basic changes will occur regarding the terms and conditions of the existing contracts even if there are future changes in legislation.

Such guidelines include the following aspects that based on the considerations that mining projects in isolated areas should not be allowed to develop into economic and social enclaves, fully integrate the mining community within the economic and social development of the region. To that end, it is necessary for companies to maximize employment of the Indonesian labor force within the limits of practicability and efficiency and to provide for education and vocational training. The percentage of foreign experts employed in management, special expertise, and technical fields is based on the results of negotiations and is subject to a joint decision by the Department of Mines and Energy, the Department of Labor, and the Department of Justice.

Companies must use domestic raw materials and products, provided that such items are competitive in price, quality, and delivery time. If material and products are imported, customs duties and other levies will be imposed. To support local business, companies must promote, support, and assist Indonesian citizens who are eager to set up companies and business activities within the contract area. In the case of gold, development of new prospects will create a greater spreading of mining activities. Because of the limited size and the relatively low investment needed, gold mining development provides a good opportunity for the formation of small ventures, which is exactly what Indonesia needs to stimulate the growth of indigenous private mining enterpreneurs. This particular consideration has caused the government to welcome not only medium-size private companies but also the smaller ones.

# Chapter 3

# MARKET ANALYSIS

## 3.1. Economic Aspects

Developing mineral economies vary enormously in population, the extent and stage of mineral exploitation, agricultural potential, and level of economic and social infrastructure. The fundamental justification for small-scale mining lies in the inherent qualities of the target segment that are of particular value for developing countries. Obviously, justification for small-scale mining is particularly great in the lowest income countries which have large unskilled populations. The important potential comparative advantage in those countries is the low labor costs which will be exploited to the extent that an appropriate technology is used.

Other benefits of the small-scale mining in the poorer developing countries are foreign exchange earnings, additional government revenues through taxes and royalties, enhanced employment, the creation of a skilled labor force, and development of new regions.

3.2. Geological Aspects

The size of deposit and the shape of the mineralization is another consideration in deciding the type or capacity of the mines. Noetstaller (1987), pointed out that the comparative advantages of a geological nature that contributes to small-scale mining are the quality of the mineral extracted and the position of the mineralization. For example, surface deposits readily accessible without overburden removal, such as placer deposits containing tin or precious mineral are favorable targets. Again, in the absence of other comparative advantages, small-scale metal mines can survive in a competitive market if the ore extracted is high grade. In the case of gold, an interesting anomaly of free world gold mine production is that when price increases, an ore with a lower gold content can be mined profitably. The ore's lower contained gold content decreases total metal production (Guzardi, 1982).

3.3. Demand Factor

For more than 5000 years, gold has been recognized as a store of wealth and insurance. It has been used for the world's monetary system for the last century and a half.

Even though gold is now officially "demonetized," many countries would still hold gold as a reserve and mint coins.

In this case, gold movement usually can be described as follows. First, gold production can be increased by producing countries to increase their central bank reserves and to improve their credit rating in the international money market. Second, countries can buy and sell gold in order to maintain gold at a specific percentage of central bank reserves. Another way is to use gold for trading, leasing, and collateral. Gold also plays an important role in many industries, especially the electronics industry.

In the private sector gold is used for small bars, medalions, coins, and jewelry. In most of the world, gold has been used historically as a store of wealth and insurance. Now it is no longer controlled, people also use it as a hedge against inflation. A conclusion that can be drawn is that demand for gold will always exist.

3.4. <u>Price Movements</u>

For 200 years, gold has profoundly influenced world monetary policy. In 1819, England adopted a gold standard and by 1877 an international gold standard had been established that lasted until 1914. In 1922 an international monetary agreement was signed which basically was a "gold exchange standard." This agreement stated that nations could include foreign currency holdings and credits in their reserves. Following this agreement, the British pound sterling and the U.S. dollar became the reserve currencies of the world. International payments began to be made in these currencies instead of in gold. In 1934, the United States devalued the dollar and established a fixed price of $35 per troy ounce for official monetary purposes. All currencies could be converted to dollars which, in turn, could be converted to gold at $35 per troy ounce. This lasted until 1967 when the price remained relatively stable because of the stable dollar and the increase of production in South Africa from 15 million to 30 million ounces per year. But, in 1968, the supply of gold at $35 per troy ounce was inadequate to finance expanding trade and to bring new gold mines into production. In addition, the Vietnam conflict for the United States had caused widespread switching from dollars to gold, draining official stocks.

In 1971 the convertibility of U.S dollars into gold at $35 per troy ounce was cancelled. As a result, currencies floated against one another, depending upon each country's economic strength. The average yearly gold price has shown unparalleled volatility over the last 23 years (see Figure 3.1).

Although based on that volatility gold must be considered extremely risky. Developing countries with small mine operations can take advantage of the situation when the price of gold is relatively high. When prices increase, an ore with much a lower gold content can be mined profitably. Figure 3.2 shows yearly gold prices in constant dollars.

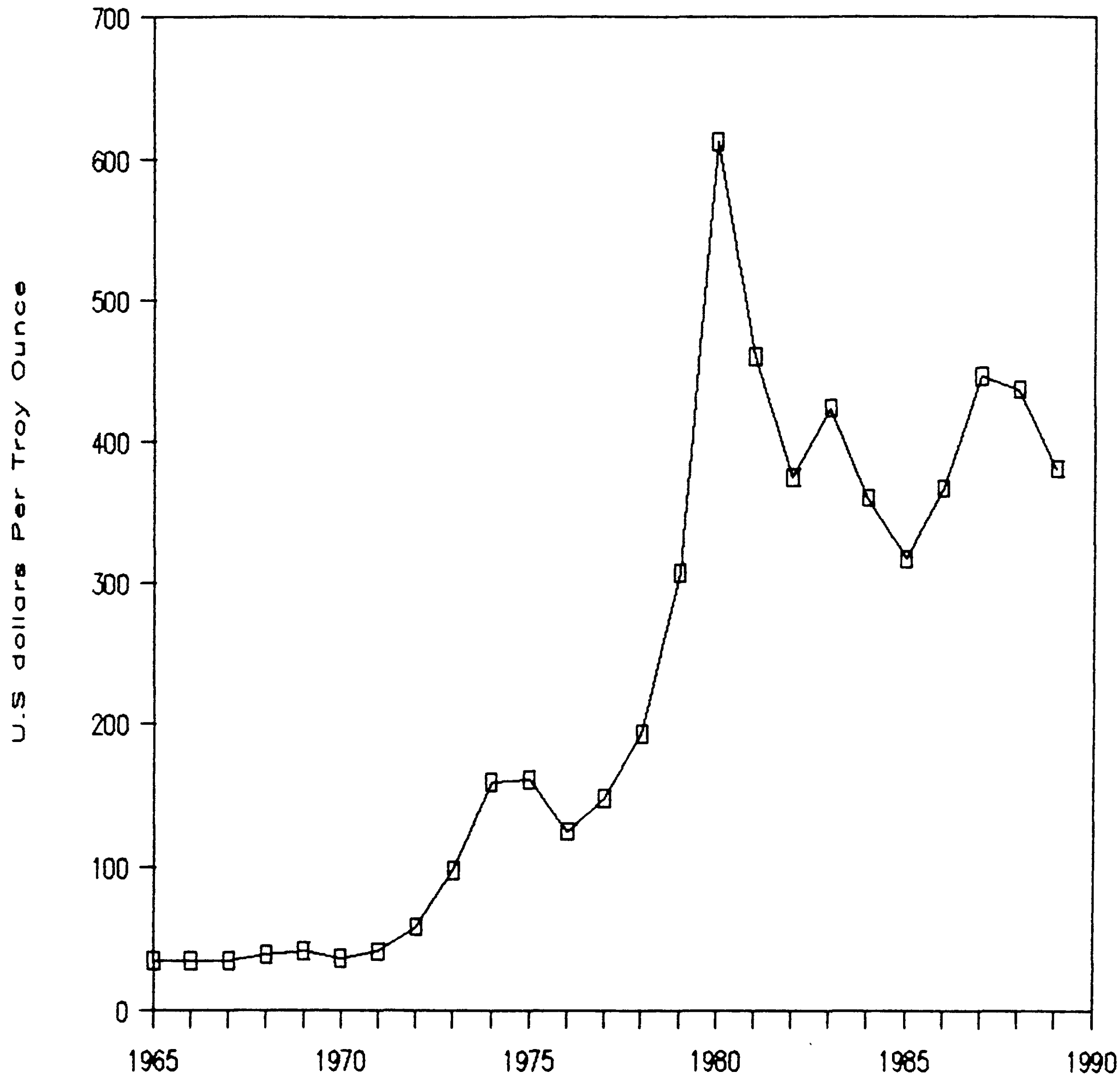


Figure 3.1. <u>Yearly Average Gold Price, 1965-1989</u>
Source: Englehard Industries.

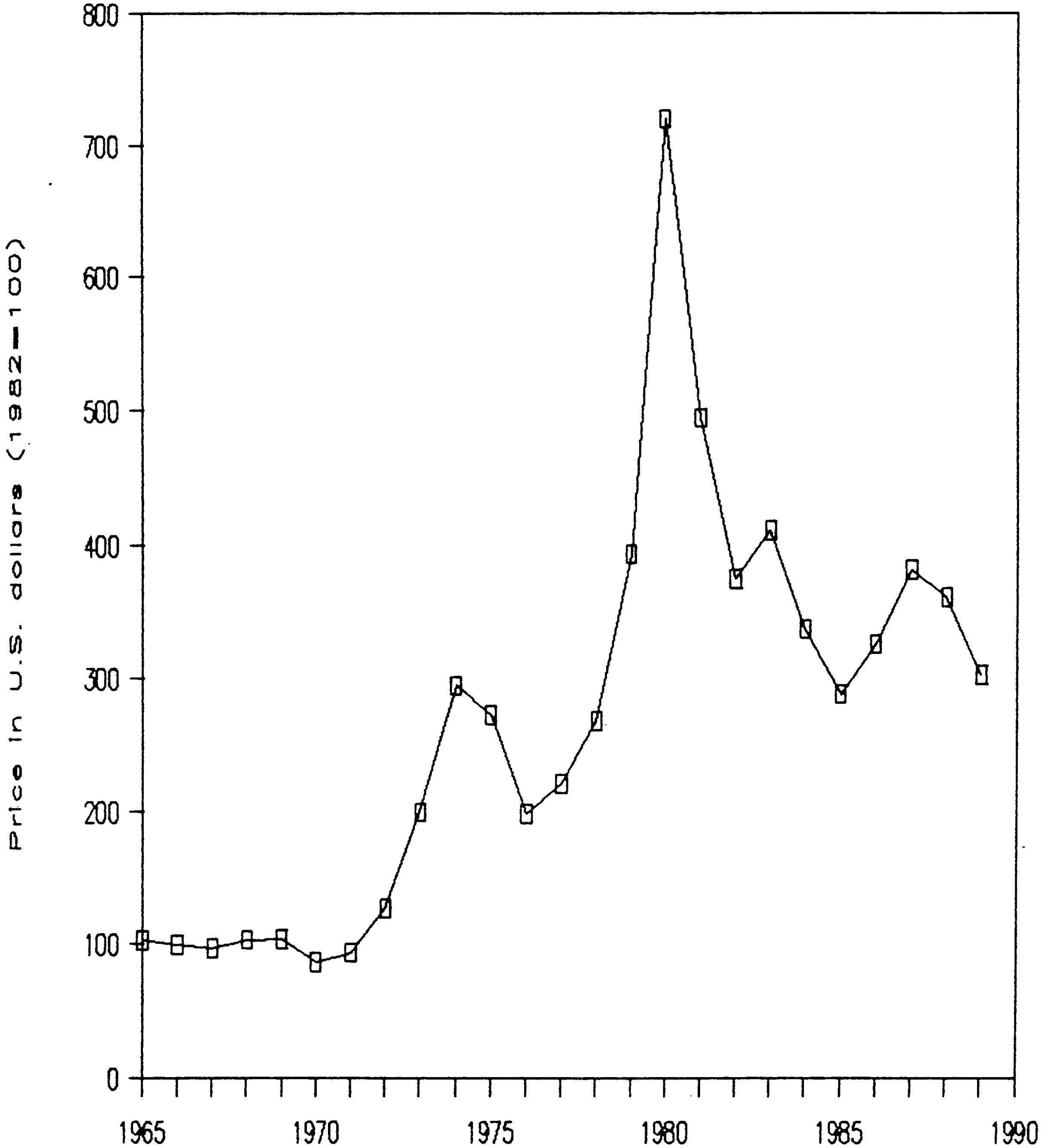


Figure 3.2. <u>Yearly Gold Prices (in constant dollars)</u>

# Chapter 4

# GOLD MINE PROJECT

## 4.1. Property Description

The gold mining project used in this study is located in central Kalimantan. This site was selected because the deposits represent the general characteristics of gold deposits cited in the previous chapter. The geological condition and reserves can be reasonably ascertained for simulation purposes. Because the site was selected for idealized modeling only, the specific place name will not be given.

Gold reserves in this area are found in alluvial deposits consisting of sandstone, mudstone, and gravel, ranging in thickness from 3 to 30 feet with an average thickness of 15 feet. Topsoil varies from 45 to 60 feet deep. Elevation of the source rock is only 15 feet above sea level. The potential in situ of gold reserves are estimated to be 16.4 million cubic meters of ore, averaging about 238 milligrams of gold per cubic meter. It is expected that 17,448 troy ounces of gold will be produced annually for the next six years.

## 4.2. Data and Operating Assumptions

The term "mining" in this context covers the operation and equipment required to excavate the alluvial material and to transport it to the treatment plant. To make a very economical operation, the unit cost of excavating, transporting, processing, and final extraction has to be exceptionally low. Dredging of material offers a low-cost method capable of high production rates. Both the nature of the alluvium and the abundance of water make it the most economical and practical method available.

The dredge will be of the Underwater Bucket Wheel Suction type. Excavation of the in situ material will be accomplished under water by means of the positive digging action generated by a large wheel with the attached bucket rotating in a vertical plane. Once the material is dislodged, it is then removed from the buckets as a low density slurry by means of a high pressure suction pump which transports it to the rear end of the dredge and then into a floating delivery pipeline and across to a treatment plant.

Lateral movement of the dredge will be accomplished by means of twin anchor lines, each attached to a fixed point on both sides of the dredge and back to the dredge ladder and then onto hydraulic winches located on the dredge pontoons. The floating delivery pipeline will be about 200 meters in length from a lined steel pipe supported by steel pontoons and containing flexible joints as necessary for the operation. The sufficient power supply for the project requirement is available from the national grid line. However, the shortest distance between this line and the mine is 15 km and the installation of a branch line and substation would be a cost to the project. Moreover, because of the overall power requirement of around 1,700 kw, the better option to be considered is the use of diesel engines as a power source.

The mine operation is designed for a land area of 485 hectares with total alluvial gold deposits of 16,425,000 cubic meters which consist of channel and terrace deposits containing grade of 238 milligrams Au per meter cubic average. The mine will operate 325 days a year, an average of 21 days a month. It is assumed that the production and deve-lopment crews and maintenance personnel will work three shifts a day. Administrative personnel will work one shift a day.

The total manpower requirement for the project is 169 workers (Table 4.1). Figure 4.1 shows the schematic flow sheet of mine activity.

Table 4.1. Manpower Requirements

| DEPARTMENT | A | B | C | D | TOTAL |
|---|---|---|---|---|---|
| Dredge | 1 | 10 | 12 | 22 | 45 |
| Process Plant | 1 | 8 | 8 | 16 | 33 |
| Gold Room | 0 | 1 | 4 | 4 | 9 |
| Maintenance | 1 | 1 | 19 | 12 | 33 |
| Administration | 4 | 5 | 8 | 5 | 23 |
| Services | 2 | 3 | 14 | 7 | 26 |
| TOTAL | 9 | 28 | 65 | 67 | 169 |

Note: A: Senior staff, department head
B: Skilled labor, supervisory level
C: Regular monthly paid staff
D: Daily paid labor

```
                        /----------\
                        |  Dredge  |
                        \----------/
                             |
    Water-------\           ore
                |            |
             /-------------------\
  Ilmenite----|   Treatment Plant   |
 /-concentrate \-------------------/
 |                           |
 |            gold concentrate (12 tonnes per day)
Storage                      |
                  /--------------\
     Hg-------   | Amalgamation |
        |         \--------------/
       Hg                    |
        |              /---------\
        \------       |Retorting|
                       \---------/
                             |
                             |
                             |
                       /---------\
                       | Furnace |
                       \---------/
                             |
                             |
                             |
                       /----------\
                       | Gold Bar |
                       |1.8 kg/day|
                       \----------/
```

Figure 4.1. Flow Sheet of Mine Activity

# Chapter 5

# ECONOMIC MODEL

## 5.1. Methodology

This study will use the discounted cash flow rate of return (DCFROR) method and the net present value (NPV) method. These discounted cash flow investment analysis techniques are the best approaches known for evaluating the economic potential of alternative investments. It is important to remember that all of the discounted cash flow techniques are systematic, quantitative approaches to evaluating investments based on given sets of assumptions and input data. The methods will be used to assess profitability of the proposed gold mining operation. Both methods are based on discounted cash flow.

DCFROR is one technique that used to evaluate the attractiveness of investments in which discounted costs equal discounted revenues, or the net present value equals zero. If the discounted cash flow rate of return is less than the discount rate, the project will not earn the required return. But, if the discounted cash flow rate of return is greater than the desired discount rate, making the project profitable, then the investment should be made.

NPV is the sum of the net cash flows for every year during the life of the operations after being discounted at the specific rate. A positive NPV from the cash flow calculation means that the proposed project is profitable or indicates a satisfactory investment.

## 5.2. Financial Assumptions

Theoretically, several factors can affect the cash flow calculation in terms of royalty rates, depreciation method, policies, equipment salvage value, escalating rates, corporate income tax rates, and the discount rate. The financial analysis provides the analytical procedures for numerous financial and accounting options. For this study several assumptions will be made.

1. Royalty rates set at 2% of gross revenue.
2. Corporate income tax rate set at 35%.
3. Development and depreciable cost expensed in year zero investment of the project.
4. Equipment depreciated according to the declining balance sheet method at 25% per year.
5. No other income exists, so losses must be carried forward

to be deducted again future income.

6. Since gold is traded internationally, gold revenues are always in U.S dollars, even though the operation costs are in Indonesian currency (rupiahs). Therefore, in this model all calculations are in 1989 U.S. dollars, with operating costs escalated at a 5% per year.
7. Seventy percent of equipment costs are paid for with borrowed money at 12% interest, paid off in equal installments in years 1, 2, 3, 4, 5, and 6.
8. Operating costs and other expenses are paid for from sales revenues.
9. Gross profits are calculated by subtracting operating costs from sales revenues.

5.3. <u>Cost Estimates</u>

An order of magnitude cost estimation was calculated for the operation in 1989 U.S.dollars. Capital and operating costs were primarily estimated based on data available from the feasibility study of P.T. Monterado (1987), Enviromental Impact Study of P.T. Ampalit Mas Perdana (1987), and from the Indonesian Mining Seminar held in 1988 in Jakarta. Basically, all costs related to this operation consist of acquisition, working capital, equipment, development, and operating costs and are shown as follows (1989 U.S. dollars).

| Equipment & Working capital | Acquisition | Evaluation & development | Operating cost |
|---|---|---|---|
| $9,326,000 | $300,000 | $1,100,000 | $1.14/m3 |

Included in the equipment costs are the underwater bucket-wheel for dredging; the bulldozer for clearing; auxiliary equipment for reclamation; pumping equipment; shop, office, warehouse, utilities, and fire protection; small vehicles; and miscellaneous supplies. Appendix A contains detailed cost breakdowns.

5.4. Revenue Estimates

The term "revenue" in this context is the amount of dollars that come from the sale of produced gold. Revenue cannot be derived from the sale of property, because all property, including plant, equipment, material and supplies purchased by the company will be used for its operation and the mining company shall have the sole use of that equipment for as long as required and is responsible for maintenance.

5.5. Sensitivity Analysis

It is important to use sensitivity analysis in dealing with the uncertainty situation for every mining operation because the discounted cash flow rate of return method in this study is primarily based on any specific assumptions of cost and revenue, whereas the analysis may not be totally accurate. Sensitivity analysis can determine to what degree changes in a parameter that is known with certainty would affect project profitability, and identifies which parameter is most critical for profitability. In this operation, parameters, such as gold price and operating cost, are considered the most critical for the operation.

For this analysis, three level estimates are used, base cost estimate, base cost plus 10%, and base cost minus 10%. Price is an important factor in determining the feasibility of gold projects. Higher prices can be anticipated because of a large reduction in mine supply as a result of an impending strike or because interest rates are declining, reducing the cost of holding gold. Higher prices also can be anticipated because of a spurt in inflation which increases the attractiveness of gold as a real asset. Lower prices will produce opposite effects. In this analysis, a conservative approach will be used in determining prices, mainly based on the assumption that there will be no big changes in the next six years. The sensitivity of the model to price change is analyzed using three price trends, US$320, US$335, and US$350 as the worst case scenarios per troy ounce, and assuming an increase of 7% per year. Since there is no official record for Beta or the risk measure for the gold mining industry in Indonesia, the rate of return to compensate the investment or the expected return on investment of this project will be based on the rule of thumb or the experience of many mining industries in Indonesia which use 15% as the appropriate rate.

The grade and recovery rate are assumed to be independent and constant over the life of the mine, even though the validity of these assumptions is a critical one. Certainly some conclusions derived from the result of this study are subject to the validity of these assumptions. The base case allows for the extraction of 2.4 million cubic meters of alluvial annually, operating a twin dredging system. Based on the mining reserves delineated to date, a six-year production life has been assumed. Using a fully recovered and diluted average grade of 238 mg/m3 with factor of 95% for fineness, an average of 17,448 troy ounces of gold will be recovered annually.

As discussed earlier, this evaluation uses the net present value and discounted cash flow rate of return methods as measurements of the economic effect of the changing factors. The combination of three price trends and three cost levels results in nine possible outcomes. The average of the net present value and rate of return for each outcome are shown in Table 5.1, with the average change in the rates of return between the different cost and price levels shown in Table 5.2.

Table 5.1. Average Rate of Return and Net Present Value

| | | | |
|---|---|---|---|
| Price at US$320.00 | Base +10% | - DCFROR | = 21.38% |
| | | - NPV (15%) | = 801 * |
| | Base cost | - DCFROR | = 27.45% |
| | | - NPV (15%) | = 1,573 * |
| | Base -10% | - DCFROR | = 33.39% |
| | | - NPV (15%) | = 2,336 * |
| Price at US$335.00 | Base +10% | - DCFROR | = 27.49% |
| | | - NPV (15%) | = 1,585 * |
| | Base cost | - DCFROR | = 33.32% |
| | | - NPV (15%) | = 2,336 * |
| | Base -10% | - DCFROR | = 39.18% |
| | | - NPV (15%) | = 3,100 * |
| Price at US$350.00 | Base +10% | - DCFROR | = 33.54% |
| | | - NPV (15%) | = 2,734 * |
| | Base cost | - DCFROR | = 39.33% |
| | | - NPV (15%) | = 3,135 * |
| | Base -10% | - DCFROR | = 44.95% |
| | | - NPV (15%) | = 3,866 * |

Note: * = (000's).

Table 5.2. Average Difference in Rates of Return

| Costs | DCFROR | Prices | DCFROR |
|---|---|---|---|
| Trend A | 6.01% | Base cost | 5.94% |
| Trend B | 5.85% | Base +10% | 6.08% |
| Trend C | 5.71% | Base -10% | 5.78% |
| Average | 5.86% | Average | 5.93% |

Based on the results in Table 5.1, the rates of return range from 21.38% to 44.95% with the net present values varying from US$801,000 to US$3,866,000. From Table 5.2, it can be seen that a change in costs can result in a 5.86% change in the rate of return. Table 5.2 also demonstrates that shifting from one price to another can result in a 5.93% change in the rate of return. A change of this magnitude is quite significant for the small mine operation. The results as measured by net present values and rates of return indicates that the project appears quite favorable.

## 5.6. Social Benefit

A highly beneficial attribute of a small-scale mining operation in a developing country is that it is more labor intensive than a large operation. In addition, a smaller operation using less sophisticated technology tends to conserve on highly skilled labor that is generally scarce in developing countries (Noetstaller 1987). Small-scale mining can contribute significantly to national employment objectives, reducing unemployment and reducing rural-urban migration (Table 5.3).

Table 5.3. Contribution of Small-scale Mining to National Employment

| Country | Persons employed in small-scale mines | Percentage of mining sector employment |
|---|---|---|
| Bolivia | 23,800 | 30 |
| Chile | 11,000 | 15 |
| India | n.a. | 47 |
| Mexico | 25,000-30,000 | 20-22 |
| Morocco | 39,400 | 40-50 |
| Peru | 40,000 | 50 |
| Philippines | 200,000 | 78 |
| Rwanda | 11,000 | n.a. |
| Zaire | 20,000-50,000 | 20-35 |

Source: Noetstaller, R. 1987. Small-Scale Mining. World Bank Technical Paper No. 75. Washington, D.C.

In Indonesia, no official record is kept of this activity; however, the current gold rush has created new hope for the gold mining industry, as long as the price of gold is in the range of $300 to $350 per troy ounce. It is anticipated that gold production within the next five years will be approximately eight tons annually based on the 103 Contracts of Work signed through 1987. Assuming that 25% of the 103 Contracts of Work areas are in production, mining gold can be considered a favorable activity. If gold prices remain high, Indonesia will certainly benefit. Small-scale mining involving management and utilization of mineral resources can be the most important base for the development of Indonesia. Small-scale mines are a source of national income and foreign exchange and can provide a starting point for the opening up and development in areas outside Java Island. Development of new regions means improvement in communications, important to national stability. Moreover, small-scale mining operations would employ large numbers of workers in rural mining districts where job opportunities are particularly scarce. Regardless of size, mining offers an opportunity for transforming unskilled labor into a semi-skilled labor force.

# Chapter 6

# CONCLUSIONS

On the basis of the results of the sensitivity analysis as measured by the average of the net present values and the average of the rates of return, the small-scale gold mining project appears profitable. Based on the minimum rate of return of 15%, the project is still in good shape. The results also demonstrate that a change in price is slightly more influential than a change in cost for the rate of return. What this means is that a reduction in operating costs is needed to compensate for the unexpected change in the price. This occurs when the actual selling price of gold is lower than the anticipated level. The reduction in operating or in capital costs will enable the mine operation to generate a sufficient return on investment.

Like any mining operation, the small-scale mine can be an attractive investment under certain economic conditions. The mine can be in production within a year or two after the discovery of gold deposits. Within such a short time, capital and operating cost estimates will not differ much from initial estimates. With a short lead time and relatively low capital requirements, a property can be put into production relatively quickly in response to an increase in the price of gold. Large-scale mines require much longer lead times, and costs tend to double or even triple over original estimates.

Revenues for any given treatment rate are determined by ore grades, plant recoveries, product prices, and market conditions at the time of selling. Ore grade and recovery efficiencies are controlled by the operator; spot prices and market fluctuations are governed by the laws of supply and demand. Furthermore, the conditions governing supply and demand can change overnight. The most vulnerable commodity in this circumstance is gold, which is generally sold on the spot market.

A great many uncertainties come from social upheavals, currency fluctuations, and predictions based upon current price levels and past trends. The magnitude of the environmental impact is generally related to the size of the mine. Small-scale mines impose less of an impact. The small-scale gold mining project will not create excessive environmental damage.

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# APPENDIX A

## Cost Estimation

## Capital Costs

(1989 U.S. Dollars)

**Equipment:**

| | |
|---|---|
| Dredging Unit (2) | = $2,628,000 |
| Pontoon Processing Plants | 5,655,000 |
| Gold Room + Laboratory | 283,000 |
| Power Plant | 73,000 |
| Fuel Storage | 70,000 |
| Tractor (1) | 30,000 |
| Trucks (4) | 42,000 |
| Office Car (1) | 15,000 |
| Motorcycles (10) | 15,000 |
| Mobile Crane | 165,000 |
| | $8,976,000 |

**Development:**

| | |
|---|---|
| Infra Structure | = $200,000 |
| Exploration | 750,000 |
| Land Clearing/Striping | 150,000 |
| | $1,100,000 |

**Working Capital:** = $350,000

**Land Rent:** = $300,000

Total = $10,726,000

## Operating Costs by Process

(1989 U.S. Dollars)

| | $/M3 |
|---|---|
| Dredging | 0.29 |
| Processing | 0.31 |
| Gold Room | 0.01 |
| Engineering | 0.11 |
| Administration | 0.16 |
| Services | 0.07 |
| Other | 0.08 |
| Contingency | 0.11 |
| Total = | $1.14/M3 |

## Operating Costs by Element

(1989 U.S. Dollars)

| | $/M3 |
|---|---|
| Labor | 0.21 |
| Fuel | 0.45 |
| Consumables | 0.19 |
| Other | 0.11 |
| Contingency | 0.17 |
| Total = | 1.14/M3 |

# APPENDIX B

## Cash Flow Summary

Cash Flow Summary at Price $320/troy ounce and operating cost $1.14/m3 (in thousands of 1989 U.S. dollars).

| Project Year Incurred | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Sales Revenue | | 5,583 | 5,967 | 6,386 |
| -Royalties | | -112 | -119 | -128 |
| Net Revenue | | 5,471 | 5,848 | 6,258 |
| -Operating cost | | -2,736 | -2,880 | -3,024 |
| -Development cost | -1,100 | | | |
| -Depreciation | | -2,246 | -1,684 | -1,263 |
| -Write off | | | | |
| -Interest rate | | -754 | -661 | -557 |
| Before depletion | -1,100 | -265 | 623 | 1,414 |
| -% Depletion | | | -315 | -707 |
| -Loss forward | | | -1,365 | -1,054 |
| Taxable Income | -1,100 | -265 | -1,054 | -347 |
| - Tax (35%) | | | | |
| Net Income | -1,100 | -265 | -1,054 | -347 |
| Depreciation | | 2,246 | 1,684 | 1,263 |
| Depletion | | | 312 | 707 |
| Loss forward | | | 1,365 | 1,054 |
| Working Capital | | | | |
| Borrowed | 6,283 | | | |
| -Principal Paid | | -774 | -867 | -971 |
| -Capital Cost | -9,626 | | | |
| Cash Flow | -4,443 | 1,207 | 1,440 | 1,706 |

(continued on next page)

| Project Year Incurred | 4 | 5 | 6 |
|---|---|---|---|
| Sales Revenue | 6,840 | 7,311 | 7,834 |
| -Royalties | -137 | -146 | -157 |
| Net Revenue | 6,703 | 7,165 | 7,677 |
| -Operating cost | -3,168 | -3,336 | -3,480 |
| -Development cost | | | |
| -Depreciation | -947 | -710 | -533 |
| -Write off | | | -1,600 |
| -Interest rate | -441 | -310 | -164 |
| Before depletion | 2,147 | 2,809 | 1,900 |
| -% Depletion | -1,005 | -1,075 | -950 |
| -Loss forward | -347 | | |
| Taxable Income | 795 | 1,734 | 950 |
| -Tax (35%) | -278 | -607 | -333 |
| Net Income | 517 | 1,127 | 617 |
| Depreciation | 947 | 710 | 2,133 |
| Depletion | 1005 | 1,075 | 950 |
| Loss forward | 347 | | |
| Working Capital | | | 350 |
| Borrowed | | | |
| -Principal paid | -1,087 | -1,218 | -1,364 |
| -Capital cost | | | |
| Cash Flow | 1,729 | 1,694 | 2,686 |

DCFROR = 27.45%
NPV = 1,573 (i=15%)

Project Cash Flow Summary at Price $320/troy ounce, operating cost plus 10%/m3

| Project Year Incurred | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Sales Revenue | | 5,583 | 5,967 | 6,386 |
| Royalties | | 112 | 119 | 128 |
| Net Revenue | | 5,471 | 5,848 | 6,258 |
| -Operating cost | | -3,000 | -3,168 | -3,312 |
| -Development cost | -1,100 | | | |
| -Depreciation | | -2,246 | -1,684 | -1,263 |
| -Write off | | | | |
| -Interest rate | | -754 | -661 | -557 |
| Before depletion | -1,100 | -529 | 335 | 1,126 |
| -% Depletion | | | -168 | -563 |
| -Loss forward | | | -1,629 | -1,462 |
| Taxable Income | -1,100 | -529 | -1,462 | -899 |
| -Tax (35%) | | | | |
| Net Income | -1,100 | -529 | -1,462 | -899 |
| Depreciation | | 2,246 | 1,684 | 1,263 |
| Depletion | | | 168 | 563 |
| Loss forward | | | 1,629 | 1,462 |
| Working Capital | | | | |
| Borrowed | 6,283 | | | |
| -Principal paid | | -774 | -867 | -971 |
| -Capital cost | -9,626 | | | |
| Cash Flow | -4,443 | 943 | 1,152 | 1,418 |

(continued on next page)

| Project Year Incurred | 4 | 5 | 6 |
|---|---|---|---|
| Sales Revenue | 6,840 | 7,311 | 7,834 |
| -Royalties | -137 | -146 | -157 |
| Net Revenue | 6,703 | 7,165 | 7,677 |
| -Operating cost | -3,480 | -3,648 | -3,840 |
| -Development cost | | | |
| -Depreciation | -947 | -710 | -533 |
| -Write off | | | -1,600 |
| -Interest rate | -441 | -310 | -164 |
| Before depletion | 1,835 | 2,497 | 1,540 |
| -% Depletion | -918 | -1,075 | -770 |
| -Loss forward | -899 | | |
| Taxable Income | 18 | 1,422 | 770 |
| -Tax (35%) | -6 | -498 | -270 |
| Net Income | 12 | 924 | 500 |
| Depreciation | 947 | 710 | 2,133 |
| Depletion | 918 | 1,075 | 770 |
| Loss forward | 899 | | |
| Working Capital | | | 350 |
| Borrowed | | | |
| -Principal paid | -1,087 | -1,218 | -1,364 |
| -Capital cost | | | |
| Cash Flow | 1,689 | 1,491 | 2,389 |

DCFROR = 22.61%
NPV = 983 (i=15%)

Project Cash Flow Summary at Price $320/troy ounce with operating cost minus 10% per m3

| Project Year Incurred | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Sales Revenue | | 5,583 | 5,974 | 6,386 |
| -Royalties | | -112 | -119 | -128 |
| Net Revenue | | 5,471 | 5,848 | 6,258 |
| -Operating cost | | -2,472 | -2,592 | -2,712 |
| -Development cost | -1,100 | | | |
| -Depreciation | | -2,246 | -1,684 | -1,263 |
| -Write off | | | | |
| -Interest rate | | -754 | -661 | -557 |
| Before depletion | -1,100 | -1 | 911 | 1,726 |
| -% Depletion | | | -456 | -863 |
| -Loss forward | | | -1,101 | -646 |
| Taxable Income | -1,100 | -1 | -646 | 217 |
| -Tax (35%) | | | | -76 |
| Net Income | -1,100 | -1 | -646 | 141 |
| Depreciation | | 2,246 | 1,684 | 1,263 |
| Depletion | | | 456 | 863 |
| Loss forward | | | 1,101 | 646 |
| Working capital | | | | |
| Borrowed | 6,283 | | | |
| -Principal paid | | -774 | -867 | -971 |
| -Capital cost | -9,626 | | | |
| Cash Flow | -4,443 | 1,471 | 1,728 | 1,942 |

(continued on next page)

| Project Year Incurred | 4 | 5 | 6 |
|---|---|---|---|
| Sales Revenue | 6,840 | 7,311 | 7,834 |
| -Royalties | -137 | -146 | -157 |
| Net Revenue | 6,703 | 7,165 | 7,677 |
| -Operating cost | -2,856 | -3,000 | -3,144 |
| -Development cost | | | |
| -Depreciation | -947 | -710 | -533 |
| -Write off | | | -1,600 |
| -Interest rate | -441 | -310 | -164 |
| Before depletion | 2,459 | 3,145 | 2,236 |
| -% Depletion | -1,005 | -1,075 | -1,118 |
| -Loss forward | | | |
| Taxable Income | 1,454 | 2,070 | 1,118 |
| -Tax (35%) | -509 | -725 | -391 |
| Net Income | 945 | 1,345 | 727 |
| Depreciation | 947 | 710 | 2,133 |
| Depletion | 1,005 | 1,075 | 1,118 |
| Loss forward | | | |
| Working capital | | | 350 |
| Borrowed | | | |
| -Principal paid | -1,087 | -1,218 | -1,364 |
| -Capital cost | | | |
| Cash Flow | 1,810 | 1,912 | 2,964 |

DCFROR = 33.39%
NPV = 2,336 (i=15%)

Project Cash Flow Summary at Price $335/troy ounce, with operating cost $1.14/m3

| Project Year Incurred | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Sales Revenue | | 5,845 | 6,246 | 6,683 |
| -Royalties | | -117 | -125 | -134 |
| Net Revenue | | 5,728 | 6,121 | 6,549 |
| -Operating cost | | -2,736 | -2,880 | -3,024 |
| -Development cost | -1,100 | | | |
| -Depreciation | | -2,246 | -1,684 | -1,263 |
| -Write off | | | | |
| -Interest rate | | -754 | -661 | -557 |
| Before depletion | -1,100 | -8 | 896 | 1,705 |
| -% Depletion | | | -448 | -853 |
| -Loss forward | | | -1,108 | -660 |
| Taxable Income | -1,100 | -8 | -660 | 192 |
| -Tax (35%) | | | | -67 |
| Net Income | -1,100 | -8 | -660 | 125 |
| Depreciation | | 2,246 | 1,684 | 1,263 |
| Depletion | | | 448 | 853 |
| Loss forward | | | 1,108 | 660 |
| Borrowed | 6,283 | | | |
| Working capital | | | | |
| -Principal paid | | -774 | -867 | -971 |
| -Capital cost | -9,626 | | | |
| Cash Flow | -4,443 | 1,464 | 1,713 | 1,930 |

(continued on next page)

| Project Year Incurred | 4 | 5 | 6 |
|---|---|---|---|
| Sales Revenue | 7,154 | 7,660 | 8,201 |
| -Royalties | -143 | -153 | -164 |
| Net Revenue | 7,011 | 7,507 | 8,037 |
| -Operating cost | -3,168 | -3,336 | -3,480 |
| -Development cost | | | |
| -Depreciation | -947 | -710 | -533 |
| -Write off | | | -1,600 |
| -Interest rate | -441 | -310 | -164 |
| Before depletion | 2,455 | 3,151 | 2,260 |
| -% Depletion | -1,052 | -1,126 | -1,103 |
| -Loss forward | | | |
| Taxable Income | 1,403 | 2,029 | 1,157 |
| Tax (35%) | -491 | -710 | -405 |
| Net Income | 912 | 1,319 | 752 |
| Depreciation | 947 | 710 | 2,133 |
| Depletion | 1,052 | 1,126 | 1,103 |
| Loss forward | | | |
| Working capital | | | 350 |
| Borrowed | | | |
| -principal paid | -1,087 | -1,218 | -1,364 |
| -Capital cost | | | |
| Cash Flow | 1,824 | 1,937 | 2,974 |

DCFROR = 33.32%
NPOV = 2,336 (i=15%)

Project Cash Flow Summary at Price $335/troy ounce, operating cost plus 10% per m3

| Project Year Incurred | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Sales Revenue | | 5,845 | 6,246 | 6,683 |
| -Royalties | | -117 | -125 | -134 |
| Net Revenue | | 5,728 | 6,121 | 6,549 |
| -Operating cost | | -3,000 | -3,168 | -3,312 |
| -Development cost | -1,100 | | | |
| -Depreciation | | -2,246 | -1,684 | -1,263 |
| -Write off | | | | |
| -Interest rate | | -754 | -661 | -557 |
| Before depletion | -1,100 | -272 | 608 | 1,417 |
| % depletion | | | -304 | -709 |
| -Loss forward | | | -1,372 | -1,068 |
| Taxable Income | -1,100 | -272 | -1,068 | -360 |
| -Tax (35%) | | | | |
| Net Income | -1,100 | -272 | -1,068 | -360 |
| Depreciation | | 2,246 | 1,684 | 1,263 |
| Depletion | | | 304 | 709 |
| Loss forward | | | 1,372 | 1,068 |
| Working capital | | | | |
| Borrowed | 6,283 | | | |
| -Principal paid | | -774 | -867 | -971 |
| -Capital cost | -9,626 | | | |
| Cash Flow | -4,443 | 1,200 | 1,425 | 1,709 |

(continued on next page)

| Project Year Incurred | 4 | 5 | 6 |
|---|---|---|---|
| Sales Revenue | 7,154 | 7,660 | 8,201 |
| -Royalties | -143 | -153 | -164 |
| Net Revenue | 7,011 | 7,507 | 8,037 |
| -Operating cost | -3,480 | -3,648 | -3,840 |
| -Development cost | | | |
| -Depreciation | -947 | -710 | -533 |
| -Write off | | | -1,600 |
| -Interest rate | -441 | -310 | -164 |
| Before depletion | 2,143 | 2,839 | 1,900 |
| -% Depletion | -1,052 | -1,126 | -950 |
| -Loss forward | -360 | | |
| Taxable Income | 731 | 1,713 | 950 |
| -Tax (35%) | -256 | -600 | -333 |
| Net Income | 475 | 1,113 | 617 |
| Depreciation | 947 | 710 | 2,133 |
| Depletion | 1,052 | 1,126 | 950 |
| Loss forward | 360 | | |
| Working capital | | | 350 |
| Borrowed | | | |
| -Principal paid | -1,087 | -1,218 | -1,364 |
| -Capital cost | | | |
| Cash Flow | 1,747 | 1,731 | 2,686 |

DCFROR = 27.49%
NPV = 1,585 (i=15%)

Project Cash Flow Summary at Price $335/troy ounce, with operating cost minus 10% per m3

| Project Year Incurred | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Sales Revenue | | 5,845 | 6,246 | 6,683 |
| -Royalties | | -117 | -125 | -134 |
| Net Revenue | | 5,758 | 6,121 | 6,549 |
| -Operating cost | | -2,472 | -2,592 | -2,712 |
| -Development cost | -1,100 | | | |
| -Depreciation | | -2,246 | -1,684 | -1,263 |
| -Write off | | | | |
| -Interest off | | -754 | -661 | -557 |
| Before depletion | -1,100 | 256 | 1,184 | 2,017 |
| -% Depletion | | -128 | -592 | -982 |
| -Loss forward | | -1,100 | -972 | -380 |
| Taxable Income | -1,100 | -972 | -380 | 655 |
| -Tax (35%) | | | | -229 |
| Net Income | -1,100 | -972 | -380 | 426 |
| Depreciation | | 2,246 | 1,684 | 1,263 |
| Depletion | | 128 | 592 | 982 |
| Loss forward | | 1,100 | 972 | 380 |
| Working capital | | | | |
| Borrowed | 6,283 | | | |
| -Principal | | -774 | -867 | -971 |
| -Capital cost | -9,626 | | | |
| Cash Flow | -4,443 | 1,728 | 2,001 | 2,080 |

(continued on next page)

| Project Year Incurred | 4 | 5 | 6 |
|---|---|---|---|
| Sales Revenue | 7,154 | 7,660 | 8,201 |
| -Royalties | -143 | -153 | -164 |
| Net Revenue | 7,011 | 7,507 | 8,037 |
| -Operating cost | -2,856 | -3,000 | -3,144 |
| -Development cost | | | |
| -Depreciation | -947 | -710 | -533 |
| -Write off | | | -1,600 |
| -Interest rate | -441 | -310 | -164 |
| Before depletion | 2,767 | 3,487 | 2,596 |
| -% Depletion | -1,052 | -1,126 | -1,206 |
| -Loss forward | | | |
| Taxable Income | 1,715 | 2,361 | 1,390 |
| -Tax (35%) | -600 | -826 | -487 |
| Net Income | 1,458 | 2,007 | 1,181 |
| Depreciation | 947 | 710 | 2,133 |
| Depletion | 1,052 | 1,126 | 1,206 |
| Loss forward | | | |
| Working capital | | | 350 |
| Borrowed | | | |
| -Principal paid | -1,087 | -1,218 | -1,364 |
| -Capital cost | | | |
| Cash Flow | 2,027 | 2,153 | 3,228 |

DCFROR = 39.18%
NPV = 3,100 (i=15%)

Project Cash Flow Summary at Price $350/troy ounce, with operating cost $1.14/m3

| Project Year Incurred | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Sales Revenue | | 6,107 | 6,543 | 6,997 |
| -Royalties | | -122 | -131 | -140 |
| Net Revenue | | 5,985 | 6,412 | 6,857 |
| -Operating cost | | -2,736 | -2,880 | -3,024 |
| -Development cost | -1,100 | | | |
| -Depreciation | | -2,246 | -1,684 | -1,263 |
| -Write off | | | | |
| -Interest rate | | -754 | -661 | -557 |
| Before depletion | -1,100 | 249 | 1,187 | 2,013 |
| -% Depletion | | -125 | -594 | -1,007 |
| -Loss forward | | -1,100 | -976 | -383 |
| Taxable Income | -1,100 | -976 | -383 | 623 |
| -Tax (35%) | | | | -218 |
| Net Income | -1,100 | -976 | -383 | 405 |
| Depreciation | | 2,246 | 1,684 | 1,263 |
| Depletion | | 125 | 594 | 1,007 |
| Loss forward | | 1,100 | 976 | 383 |
| Working capital | | | | |
| Borrowed | 6,283 | | | |
| -Principal paid | | -774 | -867 | -971 |
| -Capital cost | -9,626 | | | |
| Cash Flow | -4,443 | 1,721 | 2,004 | 2,087 |

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| Project Year Incurred | 4 | 5 | 6 |
|---|---|---|---|
| Sales Revenue | 7,484 | 8,009 | 8,567 |
| -Royalties | -150 | -160 | -171 |
| Net Revenue | 7,335 | 7,849 | 8,396 |
| -Operating cost | -3,168 | -3,336 | -3,480 |
| -Development cost | | | |
| -Depreciation | -947 | -710 | -533 |
| -Write off | | | -1,600 |
| -Interest rate | -441 | -310 | -164 |
| Before depletion | 2,779 | 3,493 | 2,619 |
| -% Depletion | -1,100 | -1,177 | -1,259 |
| -Loss forward | | | |
| Taxable Income | 1,679 | 2,316 | 1,360 |
| -Tax (35) | -588 | -811 | -476 |
| Net Income | 1,091 | 1,505 | 884 |
| Depreciation | 947 | 710 | 2,133 |
| Depletion | 1,100 | 1,177 | 1,259 |
| Loss forward | | | |
| Working capital | | | 350 |
| Borrowed | | | |
| -Principal | -1,087 | -1,218 | -1,364 |
| -Capital cost | | | |
| Cash Flow | 2,051 | 2,174 | 3,262 |

DCFROR = 39.33%
NPV = 3,135 (i=15%)

Project Cash Flow Summary at Price $350/troy ounce, with operating cost plus 10%.

| Project Year Incurred | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Sales Revenue | | 6,107 | 6,543 | 6,997 |
| -Royalties | | -122 | -131 | -140 |
| Net Revenue | | 5,985 | 6,412 | 6,857 |
| -Operating cost | | -3,000 | -3,168 | -3,312 |
| -Development cost | -1,100 | | | |
| -Depreciation | | -2,246 | -1,684 | -1,263 |
| -Write off | | | | |
| -Interest rate | | -754 | -661 | -557 |
| Before depletion | -1,100 | -15 | 899 | 1,725 |
| -% Depletion | | | -450 | -863 |
| -Loss forward | | | -1,115 | -666 |
| Taxable Income | -1,100 | -15 | -666 | 196 |
| -Tax (35%) | | | | -69 |
| Net Income | -1,100 | -15 | -666 | 127 |
| Depreciation | | 2,246 | 1,684 | 1,263 |
| Depletion | | | 450 | 863 |
| Loss forward | | | 1,115 | 666 |
| Working capital | | | | |
| Borrowed | 6,283 | | | |
| -Principal paid | | -774 | -867 | -971 |
| -Capital cost | -9,626 | | | |
| Cash Flow | -4,443 | 1,457 | 1,716 | 1,948 |

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| Project Year Incurred | 4 | 5 | 6 |
|---|---|---|---|
| Sales Revenue | 7,485 | 8,009 | 8,567 |
| -Royalties | -150 | -160 | -171 |
| Net Revenue | 7,335 | 7,849 | 8,396 |
| -Operating cost | -3,480 | -3,648 | -3,840 |
| -Development cost | | | |
| -Depreciation | -947 | -710 | -533 |
| -Write off | | | -1,600 |
| -Interest rate | -441 | -310 | -164 |
| Before depletion | 2,467 | 3,181 | 2,259 |
| -% Depletion | -1,100 | -1,177 | -1,130 |
| -Loss forward | | | |
| Taxable Income | 1,367 | 2,004 | 1,129 |
| -Tax (35%) | -478 | -701 | -395 |
| Net Income | 889 | 1,303 | 734 |
| Depreciation | 947 | 710 | 2,133 |
| Depletion | 1,100 | 1,177 | 1,130 |
| Loss forward | | | |
| Working capital | | | 350 |
| Borrowed | | | |
| -Principal paid | -1,087 | -1,218 | -1,364 |
| -Capital cost | | | |
| Cash Flow | 1,849 | 1,972 | 2,983 |

DCFROR = 33.54%
NPV = 2,374 (i=15%)

Project Cash Flow Summary at Price $350/troy ounce,operating cost minus 10% per m3

| Project Year Incurred | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Sales Revenue | | 6,107 | 6,543 | 6,997 |
| -Royalties | | -122 | -131 | -140 |
| Net Revenue | | 5,985 | 6,412 | 6,857 |
| -Operating cost | | -2,472 | -2,592 | -2,712 |
| -Development cost | -1,100 | | | |
| -Depreciation | | -2,246 | -1,684 | -1,263 |
| -Write off | | | | |
| -Interest rate | | -754 | -661 | -557 |
| Before depletion | -1,100 | 513 | 1,475 | 2,325 |
| -% Depletion | | -257 | -738 | -1,029 |
| -Loss forward | | -1,100 | -844 | -107 |
| Taxable Income | -1,100 | -844 | -107 | 1,189 |
| -Tax (35%) | | | | -416 |
| Net Income | -1,100 | -844 | -107 | 773 |
| Depreciation | | 2,246 | 1,684 | 1,263 |
| Depletion | | 257 | 738 | 1,029 |
| Loss forward | | 1,100 | 844 | 107 |
| Working capital | | | | |
| Borrowed | 6,283 | | | |
| -Principal paid | | -774 | -867 | -971 |
| -Capital cost | -9,626 | | | |
| Cash Flow | -4,443 | 1,985 | 2,292 | 2,439 |

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| Project Year Incurred | 4 | 5 | 6 |
|---|---|---|---|
| Sales Revenue | 7,485 | 8,009 | 8,567 |
| -Royalties | -150 | -160 | -171 |
| Net Revenue | 7,335 | 7,849 | 8,396 |
| -Operating cost | -2,856 | -3,000 | -3,144 |
| -Development cost | | | |
| -Depreciation | -947 | -710 | -533 |
| -Write off | | | -1,600 |
| -Interest rate | -441 | -310 | -164 |
| Before depletion | 3,091 | 3,829 | 2,955 |
| -% Depletion | -1,100 | -1,177 | -1,259 |
| -Loss forward | | | |
| Taxable Income | 1,991 | 2,652 | 1,696 |
| -Tax (35%) | -697 | -928 | -594 |
| Net Income | 1,294 | 1,724 | 1,102 |
| Depreciation | 947 | 710 | 2,133 |
| Depletion | 1,100 | 1,177 | 1,259 |
| Loss forward | | | |
| Working capital | | | 350 |
| Borrowed | | | |
| -Principal paid | -1,087 | -1,218 | -1,364 |
| -Capital cost | | | |
| Cash Flow | 2,254 | 2,393 | 3,480 |

DCFROR = 44.95%
NPV = 3,866 (i=15%).