EXPLORATION AND THE OPENING OF NEW GOLD MINES IN NEVADA, 1970-1999

by

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ABSTRACT

Mineral exploration leads to increased mineral supplies. However, not all newly discovered deposits are developed because of unfavorable economic and technological factors at the time of discovery. The timing between exploration (and discovery) to development can vary from deposit to deposit and from period to period, which affects the role of exploration in the sense of how immediate the impacts are of exploration to supply. Trocki (1989) studied new iron and copper mines opened in non-centrally-planned-economy countries since World War II. Her research shows that approximately 70 percent of new iron mines and 50 percent of new copper mines did not result from the orderly development of new discoveries. The mine openings resulted from the revaluation of mineralization or ore bodies that were known for years, but which only become economic after technological and economic conditions changed. The role of exploration to supply associated with Trocki's conclusions led to the objectives of this study, first, whether her conclusions can apply to other mineral commodities, study periods, and location, and second, what is the relationship of exploration to the new mine openings.

This research is concerned with how exploration affects gold supply by studying the history of new gold mine openings in Nevada during the 1970-1999 period. This study introduces a new classification method called "two-dimensional classification." It considers two important factors: lead time and proximity of new mine openings, to distinguish between mines opened from the revaluation of previously mined or previously known deposits or mineralization (called "old field" in this study), and from prompt development after discovery (called "new field" in this study). In addition, unlike Trocki, who used number of mines as a criterion, this study used production as a criterion.

The results of the study here of Nevada gold mines shows that 76 percent of total past production during the study period, 1970-1999, comes from the "new field" category, which indicates prompt development after discovery, with an average lead time of less than five years. Three important factors might differentiate the final results from Trocki's results: analysis method, period of study, and type of mineral study. The research also shows that the difference in study period is a critical factor in the different outcomes. A specific study period of Trocki's between 1955 and 1975 regarding copper mine openings gives the same results as this study because of a similarity in technological innovations that applied to a specific new type of deposit. More specific, an application of heap leaching to the disseminated gold deposits is similar to the application of heap leaching, SX-EX and oxygen "flash" smelting to massive sulfide copper deposits. Some periods of iron mine openings indicate similar results, but they are less obvious than those of copper mine openings.

The role of exploration to supply has changed with time. Exploration managers can learn from the history of mine openings to answer where and what type of deposits may be effectively explored under comparative circumstances. On the other hand, policy makers who desire a sustainable mineral industry should support not only exploration, but also research for technological innovations, which may apply to both existing and future deposits.

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Chapter 1
INTRODUCTION

Talk of mineral exploration often brings up fears of ore depletion. True, mineral sources are finite. But what the industry is finding, aided and abetted by researchers, is that previously known, uneconomic deposits can become sources of new supply under favorable economic conditions and advanced technologies. Researchers who study the history of new mine openings have found that a large percentage of new openings in more recent times are from old mines previously thought exhausted. Linda Trocki in a 1990 landmark study found that since World War II, one-half of all new copper mines and two-thirds of all new iron mines that opened in non-centrally-planned economies occurred from the revaluation of old worked-out mine sites.

Trocki's study provided the inspiration here for studying the history of gold mine openings, specially a study of gold mine openings in the state of Nevada where most of the country's gold exploration takes place. The study here attempts to find answers to several questions, one being on whether Trocki's findings regarding new iron and copper mine openings apply in any way to new gold mine openings. The hope is that researchers will study other minerals to discover whether Trocki's findings are relevant to other minerals.

1.1 Problem Description

Trocki results imply that role of exploration is probably more complicated and less immediate to mineral supply. New mineral deposits are not all promptly developed after they are discovered. For instance, many new reserves come from the revaluation of previously known but uneconomic deposits. Many past studies concerned with depletion of minerals show that exploration is an important key in increasing the mineral supply. More specifically, exploration needs to uncover new deposits for immediate development and production. Consequently, when supply increases, price will be theoretically suppressed. However, not every exploration and discovery of new deposits is followed by immediate development and production stages. Many factors are involved and exploration (and discovery) cannot simply be treated as the only means of increasing supply.

Studies incorporating Hotelling's theory of exhaustible resources can be found in Fisher (1964, p.10-74), Erickson and Spann (1971), MacAvoy and Pindyck (1973, p.454-498), Pindyck (1978, p.841-863) and Dasgupta and Heal (1974, p.3-28 and 1979). These studies characterize exploration as the only process for expansion of supply capacity. Trocki (1990) argues that these studies ignore the uncertainties about how many resources exist that could be economically recovered.

1.2 Specific Problem

The role of exploration to mineral supply may have changed over time under difference circumstances, such as changes in supply and demand, mineral prices, and technological improvements. An application of Trocki results should be studied by looking at other periods of time and different mineral types to add a variety of circumstances that may alter the results.

If new mines were developed promptly from a new discovery of deposits, this action might support the assumption that a scarcity of mining supply probably arises if exploration fails to uncover new deposits. On the other hand, if new mines were developed from the project revaluation of previously known mineralization or deposits, the role of exploration could be more complicated and less immediate to mineral supply than many prior indications as Trocki indicated. Figure 1 may help to clarify the two different sources of supply discussed above.

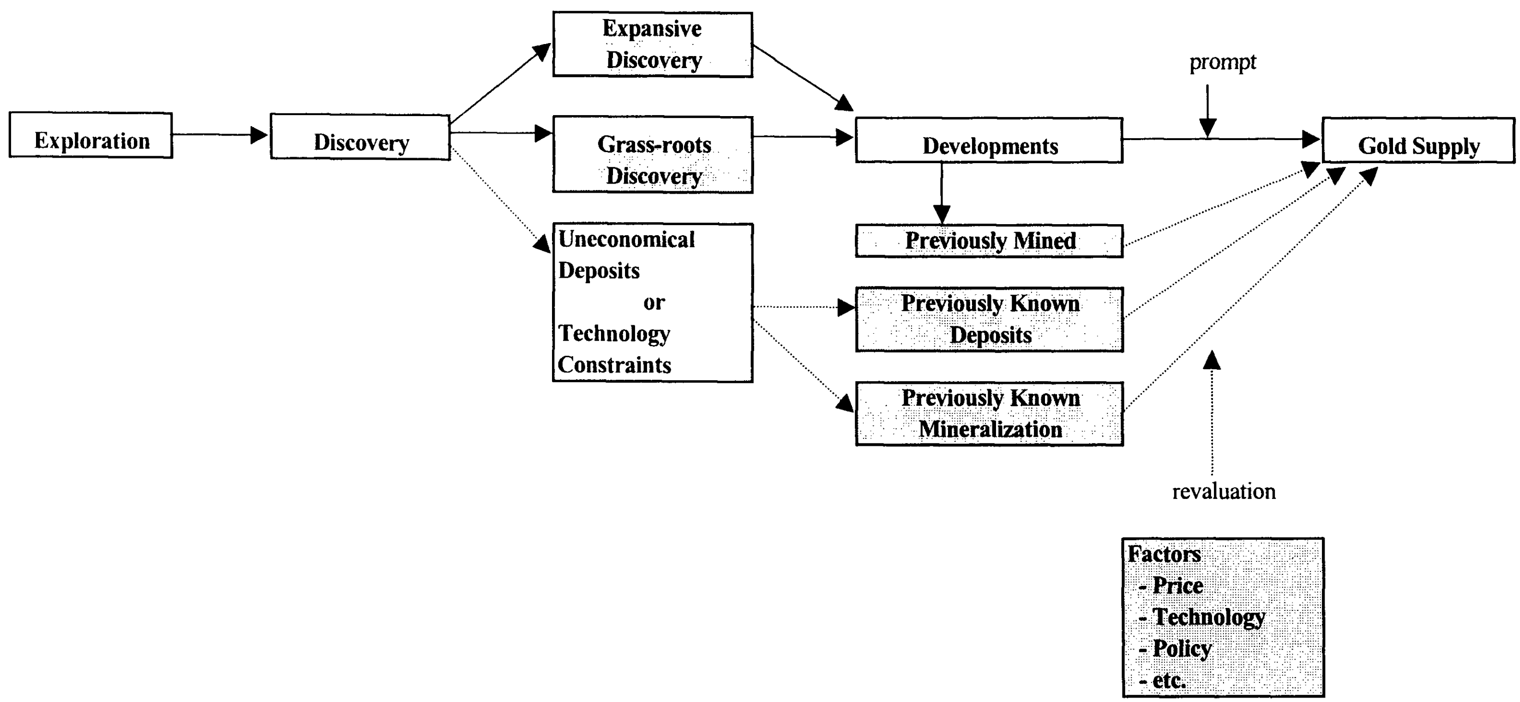

Figure 1 Basic Supply Processes and Possible Sources of Gold Supply

1.3 Purpose and Scope

This study investigates the development history of newly opened gold mines in Nevada since 1970 in order to determine the relationship between exploration and the openings.

The thesis will study:

(1) The development history of gold mine openings in Nevada in order to identify whether they were promptly opened from the continual processes which were exploration, discovery, development, and production. This study sets the hypothesis that mine openings mostly (more than 50 percent of the past verified total production) resulted from the reevaluation of mineralization or ore bodies that had been known for years, and which became economic under changed technologic or market conditions, not from prompt development after discovery. If the hypothesis is correct, the studies that predict a scarcity of resources arising from the failure of exploration to uncover new deposits do not adequately explain the mineral supply process.

(2) The study will further try to discover the source of these mines,-new discoveries or reevaluation of previously worked mines-especially for the increased mine openings of the 1980s and what roles the prompt development of grass-roots discoveries or the expansive discoveries played. For the sake of comparison, what roles the revaluation of known mineralization and deposits played will be studied as well.

(3) Trocki (1990) analyzed the openings of copper and iron mines in the non-centrally-planned economies since the mid-1800s and the results showed that approximately 70 percent of the new iron mines and 50 percent of the new copper mines opened did not result from the orderly development of new discovery. She calculated by using the number of new mine openings and weighed each mine opening equally (one), regardless of mine production. She claimed that the conclusions of her study were considered to be applicable (probably during her

periods of study) to other metals, *including gold.* Even though her study supported the hypothesis stated above (1), her conclusions might have come out differently had she used mine production in her study, instead of the number of new mine openings. The study here will verify whether her conclusions are applicable to the gold market when using mine production as a criterion applied to a different period of time (1970-1999) and a specific location (Nevada).

Approximately 106 new mine openings were studied and classified. The definition of new mines used in this study includes mines that reopened after having been closed for more than 5 years. The classification scheme was designed to distinguish among such cases as prompt development of discovery, revaluation and development of old discovery, or reopening an old mine. The further study will try to answer why these new mines were developed at a particular time.

This study will focus mainly on gold produced from metal ores (gold ores, copper ores, or base metal ores) in Nevada. Gold produced from alluvial or placer deposits will be excluded because that production is insignificant in Nevada during the period of study. The development history includes data on mine production, names, locations, owners or operators, deposit types, discovery years, years of starting production, and grade of produced ore or reserve. New opening mines were classified consistently by mine-by-mine information, using the Trocki (1990) classifications and the newly adapted method of classification called "two-dimensional classification."

The two-dimensional classification adds two factors: lead-time and proximity. These two factors are applied to the Trocki classification to create more consistency. Methodology used in the Trocki study and this study will remain the same, but methods used are slightly different. The analytical method will be thoroughly discussed in a separate chapter.

Newly opened gold mines in Nevada since 1970 have been roughly explored and examined as to how their roles affect gold supply. The preliminary study indicates that the timing of opening a new mine is related not only to when exploration and discovery happens but also to other economic factors, such as mineral demand and prices. Potential sources of gold supply have changed depending upon the changes of economic and technological factors. Exploration targets have also been adapted to maximize every dollar spent in searching for high-yield gold deposits. The supply process is a combination of many integrated processes, and exploration is a part of the supply process.

1.4 Gold Production in Nevada, 1970-1999

Nevada has been a major gold-producing state since the "Comstock" era started in 1860, followed by the "Goldfield" deposit between 1897 to 1920 and the latest world-class "Carlin" deposit started in 1965 and still operating. In 1999, Nevada's production of gold was approximately 75 percent of the United States total, and Nevada alone accounted for 10 percent of world production (Price and Meeuwig 1999, p.3-6). Exploration and new nine openings in Nevada in the past 20 years have played a significant role in bringing about the enormous gold production today, even though a few new mines have opened in Nevada over the last five years.

From 1994 through 1999, a few new gold mines in Nevada were developed from both grass-roots exploration and brownfield exploration.[1] From these new mine openings, only one mine was developed from grass-roots discovery; the rest were developed from brownfield discoveries. The grass-roots discovery found in 1994 was called the "Pipeline" deposit and the following expansive discovery was called the "South Pipeline" deposit. These discoveries led to the opening of 12 new mines-Kinsley, Pipeline (and South Pipeline), Ruby Hill, Mule Canyon, Rose Bud, Ken Snyder,

[1] Grass-roots or greenfield exploration is an exploration in new areas, while brownfield exploration is an exploration in established mining districts using more sophisticated technology not previously available (Wilburn, 2001). In this study, brownfield exploration includes exploration that focuses on or around existing property or operating mines.

SSX Jerrit Canyon, Turquoise Ridge, Mineral Ridge (halted in 1999), Trenton Canyon (one of the Lone Tree Complex), Olinghouse and Griffin Gold. The last two mines first produced in 1998 and closed within less than a year (Tingley and LaPointe 1999, p.10).

In 1999, identified gold production in Nevada was 8,258,277 ounces (Tingley and LaPointe 1999, p.10), a seventeen-fold increase over identified production in 1970 (480,073). Six major mines operated at the beginning of 1970-Carlin, Copper Canyon, Cortez, Big Mike, and Tripp and Veteran Pits of Kennecott but only Carlin and Cortez produced gold from gold ores. The others were copper mines for which gold was a byproduct. Since 1970 more than one hundred mines have been developed, and only the Carlin and Cortez mines are still producing and have been able to replace their reserves.

In this study of mine production, mine output will be examined in five-year periods beginning with 1970 and ending with 1999 (Table 1.1 and Appendix A). Mines will be classified as either "new" or "existing." For example, a mine opened in 1970 through 1974 will be classified as "new" for the period 1970-1974. If it is still operating in 1975, the beginning of the next period, its classification will change to "existing."

Gold production from new mines opened during the 1980s contributed significantly to the gold supply. In the period of 1980-1984 and 1985-1989, new mine production contributed 59 percent and 40 percent of the total identified production.[2] Nearly fifty new mines were developed in 1985-1989 alone. During the period 1980-1984, production from new mines contributed nearly 90 percent of the *incremental production*[3] from the previous period. These new mines, such as Alligator Ridge, Jerritt Canyon, Betze-Post and Pinson, have been continually and significantly producing gold in the last decade. The classification of incremental production is illustrated in Table 1.2. The negative incremental production of new mines indicates less production from new

[2] The identified production is the reported or carefully estimated production from operating mines, which total identified production will, mostly, less than state (Nevada) production because not every mine production can be obtained.
[3] The incremental production is the total production change from one period to the next period.

Table 1.1 Classification of Production of Existing Mines and New Mines in Five-Year Period

	1970-74		1975-79		1980-84	
	ounces	**%**	**ounces**	**%**	**ounces**	**%**
Total Identified Gold Production	1,832,798	100	1,429,721	100	3,445,632	100
Of which:						
- From mines in operation at beginning of 5-year period	1,747,525	95	1,180,601	83	1,399,865	41
- New mines	85,273	5	249,120	17	2,045,767	59
	1985-89		**1990-94**		**1995-99**	
	ounces	**%**	**ounces**	**%**	**ounces**	**%**
Total Identified Gold Production	14,679,473	100	31,889,724	100	38,557,372	100
Of which:						
- From mines in operation at beginning of 5-year period	8,855,672	60	29,310,461	92	37,184,928	96
- New mines	5,823,801	40	2,579,263	8	1,372,444	4

Sources:
1. American Mines Handbook 2000 for 1997-98 data
2. Disseminated/Replacement Gold Deposits, 1981, Minobras Mining Services
3. Economic Gold Deposit, 1984, Minobras Mining Services
4. Financial Times, Energy Yearbooks, Mining 1999 p.273-274
5. Gold Discoveries, 1970-1989, Roderick G. Eggert and Alan Casey
6. Gold Guidebook for Nevada and Utah, 1982, Minobras
7. Gold Mines of the World, 1981, Minobras Mining Services
8. Major Mines of Nevada, Nevada Bureau of Mines and Geology
9. Minerals Yearbook USGS.
10. Newmont Gold Company Annual Report and Form 10-K
11. Radol Mining Directory, 1990/91, 1993/94, 1995/96, 1997/98, 1999.
12. Valcanogenic Gold Deposits, 1982, Minibras Mining Services
13. World Gold Vol.I, 1988, Minobras Mining Services
14. 2000/01 Western Mining Directory

Table 1.2 Classification of Incremental Production of Existing Mines and New Mines in Periods of Increased Production

	1980-84		1985-89		1990-94		1995-99	
	ounces	**%**	**ounces**	**%**	**ounces**	**%**	**ounces**	**%**
Incremental Production	2,015,911	100	11,233,841	100	17,210,251	100	6,667,648	100
Of which:								
- From mines in operation at beginning of 5-year period	219,264	10.9	7,455,807	66.4	20,454,789	119	7,874,467	118
- New mines	1,796,647	89.1	3,778,034	33.6	(3,244,538)	-19	(1,206,819)	-18.1
Number of New Mines	16		47		19		12	

Sources:

1. American Mines Handbook 2000 for 1997-98 data
2. Disseminated/Replacement Gold Deposits, 1981, Minobras Mining Services
3. Economic Gold Deposit, 1984, Minobras Mining Services
4. Financial Times, Energy Yearbooks, Mining 1999 p.273-274
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mines compared to its previous production, so totally incremental production came from the existing mines alone.

1.4.0 Gold Prices and Exploration Expenditures

Gold price obviously plays an important role in new mine openings. The average gold price peaked in 1980 at $612.56 per ounce[4] and stayed at or above the $360 level for almost 10 years (except in 1985). The high gold price is a factor that allows gold producers to spend more on exploration, and consequently increase the successful rates of exploration. Successful exploration can lead to the discovery of new high-rent deposits and that can be rapidly developed. The number of new mine openings increased rapidly during the period 1980-90, more than 60 mines compared to fewer than 10 mines during the 1970s. On the other hand, many new uncovered deposits were possibly left untouched because they were uneconomic or the technology required may not have been available.

With gold prices now at low levels relative to recent gold prices, exploration expenditures have decreased over the past several years (Table 1.3). Exploration patterns in Nevada have changed to maximize the successful rate of exploration within an available budget. A recent survey of gold exploration in Nevada[5] indicates that the large exploration companies tend to replace their depleting resources by focusing on brownfield explorations rather than on grass-roots explorations. Barrick Gold Corporation indicates that corporations will commit $90 million to exploration, focusing on or near existing properties to take advantage of existing processing facilities and infrastructure (Mining Record, 2000). Tingley and LaPointe (1999, p.10) also indicate that Nevada exploration activities in 1999 followed the same pattern over the past few

[4] Average gold price from Engelhard Industries Quotation.
[5] Conducted annually by the Nevada Division of Minerals, Commission on Mineral Resources, State of Nevada. See page 6 of the 1999 survey.

Table 1.3 Estimated Exploration Expenditures in Nevada and the United States, 1980-1999 (millions of current U.S. dollars)

Year	Previous Survey (1)	United States (2)	Nevada (2)	Average Gold Prices
1980	316.41			612.56
1981	364.56			459.64
1982	302.61			375.91
1983	276.57			424.00
1984	206.42			360.66
1985	98.38			317.66
1986	104.20			368.24
1987	110.20			447.95
1988	178.03			438.31
1989	135.17			382.58
1990	146.99			384.93
1991	130.33			363.29
1992	n/a			344.97
1993	n/a			360.91
1994		206.00	154.00	385.00
1995		197.00	140.80	386.00
1996		158.30	120.90	389.00
1997		226.40	138.80	332.00
1998		119.30	90.80	295.00
1999		107.30	86.70	279.91
2000		120(e)	102(e)	280.10

Note: Average gold prices in current U.S. dollars per ounce; (e) means estimated values.

Sources:

1. Previous survey from Annual Mineral Exploration Statistics-United States and Canada Companies 1980-1992 conducted annually by the Society of Economic Geologists, published in Economic Geology journal.

2. Data of United States and Nevada from Annual Exploration Survey 1994-1999 conducted annually by Nevada Division of Minerals, Commission on Mineral Resources, State of Nevada.

years, which mainly concentrated along the previous large producing areas-Battle Mountain, Carlin, Getchell and Midas trends.

Grass-roots exploration seems not to be an option for operating gold companies because of high risks. Besides that, brownfield exploration has been working relatively well in replacing the reserves lost to production. More than 50 percent of the respondents to the Nevada survey were able to totally replace their output with new reserves (Driesner 1999, p.6).

Chapter 2
LITERATURE REVIEW

Past studies related to exploration and mineral supply can be categorized as either theoretical or empirical. Most theoretical studies extend the Hotelling (1931, p.137-175) model of exhaustible resources to include exploration. Empirical studies generally analyze exploration as an economic activity, in which trends, expenditures, and effectiveness of explorations are favored topics.

2.1 Theoretical Studies

Past works have extended the basic Hotelling model in a variety of applications. Hotelling (1931) first demonstrated that with constant marginal extraction costs, price minus marginal cost should rise at the rate of discount in a competitive market, and rent[1] should also rise at the rate of discount in a monopolistic market. One of Hotelling's assumptions is a fixed reserve base; on the other hand, no uncertainty about the reserve but, in fact, reserves can be increased with economic incentives. A particular concern has been about the effects of resource uncertainty on the rate of extraction and what the optimal rates of extraction should be.

Gilbert (1976) and Heal (1976, p.371-378 and 1978) examined the characteristics of extraction paths under a fixed reserve. Gilbert (1976) applied the use and values of exploration to obtain a better estimate of the size of the fixed reserve. Dasgupta and Stiglitz (1976) and Heal (1978) in their models studied the optimal extraction paths when a substitute for the resource is possible, under alternative market structures. Dasgupta

[1] marginal revenue minus marginal cost

and Heal (1974, p.3-28 and 1979) expanded more assumptions on the uncertainty of the future resource base and predicted discontinuous shifts in price paths resulting from exploration. Even though the authors realized that reserve should not be fixed, the realistic model that incorporated exploration to the reserve uncertainty could not easily be set, especially in the mathematics model. All the studies examined how producers should exploit a fixed reserve base over time.

Pindyck (1978, p.841-863) recognized that reserves could be maintained or increased through further exploration. He treated the reserve base as the basis for production and exploratory activity as the means of increasing or maintaining reserves. He also treated depletion by assuming that reserve additions ("discoveries") resulting from exploratory activity fall as cumulative discoveries increase. Given these constraints, resource producers must simultaneously determine their optimal rates of exploratory activity and production. He concluded that (if the initial reserve endowment is large) the introduction of exploratory activity has the effect of reducing the rate of increase of price. In other words, price will increase if the exploration fails to discover new mineral deposits. This model oversimplifies the supply process because exploration is not the only means of increasing mineral supply.

2.2 Empirical Studies

Many of the following empirical studies of exploration analyze exploration trends, expenditures, and the ways exploration is related to mineral supply. Such studies include the work of Eggert (1987), Rose and Eggert (1988, p.331-362), Crowson (1988, p.21-103), MacKenzie and Woodall (1988, p.363-418), and Cranstone (1988, p.283-330). These works often use the value of discoveries as a measure of success and a means of reserve additions. However, exploration alone cannot guarantee a sufficient mineral supply in the long run because the timing gaps of discovery, development, and production periods are also important to mineral supply.

Rose and Eggert (1988) examined exploration trends in the United States. They concluded that exploration for the majority metals had been episodic in the 1900s. The key influences were the discoveries of a few large deposits, successful exploitation, and changes in mineral demand.

Crowson (1988) examined exploration expenditures for the non-centrally-planned economies for the period 1965-1982. He summarized that mineral demand and prices significantly influenced the expenditures. He referred to the peaks in exploration in the early 1970s and 1980s and the trough in 1975 associated with the recession as proof of his hypothesis of exploration expenditure.

Mackenzie and Woodall (1988) studied mineral exploration in Canada and Australia. The authors compared the success of exploration in the two countries by using an index of exploration productivity.[2] They concluded that exploration in Australia had been less productive compared to Canada.

Cranstone (1988) studied mineral exploration in Canada in the post-World War II era. He concluded that the productivity of exploration had not declined during the period and the cost of exploration per unit of metal had remained constant. He also believed that geophysical methods were the keys behind the success of mineral exploration in Canada.

Trocki (1990) analyzed the development histories of approximately 200 iron and copper mine openings in non-centrally-planned economies from the mid-1800s through the mid-1980s to determine the role of exploration in mineral supply. The study showed that approximately 75% of iron mines and 50% of copper mines that opened after World War II did not result from the prompt development of new discoveries. The mine openings resulted from the reevaluation of previously known mineralization, which became economically viable. Trocki argued that the studies that predicted resource scarcity arising from the failure of exploration to reveal new profitable deposits did not sufficiently explain the mineral supply.

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[2] The cost of exploration and development divided by the estimated value of discoveries generated from production.

The contribution of exploration seems to be more complicated to mineral supply than shown in the prior studies. A question arises about the fact that the interrelationship between exploration and mineral supply always be linked to the development and production stages and time. Many previous studies that analyzed and treated exploration and its success, discovery, as a portion of mineral supply were not totally true. Moreover, the success of exploration measured by the number of discoveries can do nothing to mineral supply if the discoveries have not been developed. However, the discoveries of new deposits can lead to the increasing of stock values of the company, and can count as the success of exploration in a short-run period. Many discovered deposits were left behind as previously known deposits or previously known mineralization because of unfavorable economic conditions, such as mineral prices, government policies and interest rates.

Chapter 3
MINERAL DEVELOPMENT AND EXPLORATION

This chapter summarizes the mineral development process in order to grasp the basic relationship between exploration and a new mine opening. Some characteristics of mineral exploration and exploration methods are discussed to provide some information on the timing and limitations of mineral exploration. Basically, opening a new mine requires both financial and mining feasibility studies. Besides that, a new mine can be opened from new discovery deposits or from previously mined or known deposits. The timing of the opening of a new mine is related to feasibility studies and geological information of mineral deposits. Mineral development is complex, involving many participants and resources. It consists of three phases: *exploration, deposit development, and mine development (exploitation)* (Vallee, et al., 1992, p.1-9).

3.1 Mineral Development Phase

Exploration is the first phase of the process that may culminate in the discovery of a mineral deposit. Deposit development follows and ends when the feasibility studies of both mining and the economics of a mining project are established. Mine development and exploitation are the final phases.

3.1.1 Exploration

In the exploration phase, geologists and authorities cooperate to establish a mineral target and mineral potential of a specified geological area. The initial exploration

Table 3.1 Mineral Development Process

	RESOURCES							RESERVES		
	HYPOTHETICAL		INFERRED		DELIMITED			PROVEN AND PROBABLE		
PHASE	EXPLORATION				DEPOSIT DEVELOPMENT				EXPLOITATION	
STAGE	1	2	3	4	5	6	7	8	9	10
DESCRIPTION	Regional surveys	Anomaly prospecting	Anomaly, Showing verification	Discovery, Delimitation	Deposit definition	Project engineering	Project economics	Feasibility, Decision	Mine development	Mine exploitation
EVALUATION METHODS	Regional reconnaissance survey, geological, geochemical, geophysical surveys and inventories.	Ground survey, staking, geology, prospecting, geochemistry, geophysics.	Staking, detailed surveys, trenching.	Stripping, trenching, sampling, drilling.	Detailed mapping, sampling, drilling on surface or underground.	Engineering studies. Pilot tests, mine and plant design.	Extraction policy. Market, price, and cost surveys; social and political constraints.	Review of geological, engineering, economic, legal, financial and site data. Evaluation and decision.	Construction of mine/mill infrastructures; pit/mine development.	Mine planning, development. Exploitation, sales
EVALUATION OBJECTIVES	Find regional or sector anomalies.	Locate and confirm anomalies.	Property acquisition. Anomaly, and showing verification	Discovery, Confirmation, and first delimitation of a MINERAL DEPOSITS.	Establish limits, distribution, mineralogy, grade, and controls of mineralization.	Engineering planning and parameters for mining, milling, environmental protection.	Establish parameters of economic evaluation.	Complete and appropriate project review, Decision on basis of NPV and Risks factors.	Prepare commercial exploitation.	Efficient management, profitability, company survival.
GLOBAL MARGIN OF ERROR				40%	30%	20%	10%			
FEASIBILITY STUDIES				+,- 100%	+,- 60%	+,- 40%	+,- 20%	+,- 10%		
RESULT				MINERAL DEPOSIT	GEOLOGY	ENGINEERING	ECONOMICS	MINING DEPOSIT		PRODUCING MINE

Source: Modified from the stages of mineral development proposed by SOQUEM 1977 (SOCIETE QUEBECOISE D'EXPLORATION MINIERE) from Guide to the Evaluation of Gold Deposits, page 3.

work is the regional survey to seek a mineral target in a given region or country. The process commonly involves obtaining and compiling geological, geochemical, and geophysical information about the target area. The ground investigations of the anomaly or showings can be trenching and sampling. If the investigations are promising, drilling will be the next step. Primary drilling and sampling are executed at this stage on a fairly broad grid to outline and characterize the mineralization without going to more expansive methods. After the first intersections of a mineral deposit, the objective becomes the delimitation of the deposit (Vallee, et al. 1992, p.6).

3.1.2 Deposit Development

The deposit development phase begins with the definition of the deposit in detail by systematic and closely spaced drilling and sampling. The increasing density and amount of quantitative geological information allows volume and grade estimates that are based on geostatistical methods. The project engineers step in to design mining, ore processing, metallurgical methods, and environmental safeguards. Economic considerations and feasibility studies are essential before the start of a mining project. Mineral prices, market supply and demand, and capital and operating costs are the key elements that determine the profit versus grade and reserve determination (Vallee, et al. 1992, p.7).

3.1.3 Mine Development

Mine development and exploitation are the two final stages. Development must strictly follow the figures, plans, and budgets of the project. At the same time, the continued acquisition of geological data is essential to ensure efficient mine development and exploitation. A considerable amount of factual information becomes available during the exploitation stage. Geologists and project engineers must integrate the information to obtain a proper prospective of the project (Vallee, et al. 1992, p.9).

The time required for exploration and development depends on the size and location of the project, assuming conventional ore type. Gocht, et al. (1988, p.24-25) indicated that the time requirements could be roughly estimated as follows:

1. Small deposits. From 2 to 3 years for exploration and from 1 to 2 years for development of mine and processing facilities.
2. Medium-size deposits. From 3 to 4 years for exploration and from 2 to 4 years for preparation of infrastructure, mine, and processing facilities.
3. Large deposits. From 5 to 10 years or more for exploration and from 5 to 8 years or more for preparation of infrastructure, mining, and mineral processing facilities.

From these estimates, discovery and development of a project can range from at least 3 years to more than 20 years. A longer time requires a sufficient budget for carrying out the project, especially in cases lacking sufficient infrastructure and qualified personal, or when extreme climatic conditions exist.

Gocht, et al., also indicate firstly that the motivations for exploration are different between companies and government agencies. Basically, the private company seeks mineral deposits that yield an economic profit or provide secure mineral supplies. On the other hand, government agencies may be motivated by political and societal concerns rather than by economics. For instance, governments may have in mind the creation of employment opportunities, the assurance of an adequate supply of strategic minerals, or the earning of foreign exchange.

Second, the methods used to find and evaluate mineral deposits are resource-specific. For example, exploration approaches and costs for metallic ores and for petroleum are different. Also, different metallic resources require fundamentally different methods of exploration. For instance, deposits of copper, lead and zinc use one method, and deposits of silver and gold use another.

Third, the authors believe that most mineral deposits located near the surface have been discovered and that exploration trends are toward mineral deposits that are less exposed or located in the subsurface levels. The new exploration tools, which allow both a deeper penetration and a higher resolution of geologic, geochemical, and geophysical signals, are increasing in use as shown in Table 3.2, which illustrates the discoveries of *non-ferrous metal* deposits in both United States and Canada from 1951 to 1975 by principal exploration methods. Eggert, et al. (1991, p. 2-3) illustrates the discoveries of *gold* deposits in the United States and Canada from 1970 to 1989 by exploration methods (shown in Table 3.3), but the discovery methods were classified into only prospecting and systematic methods. These tables show the growing importance of systematic explorations because the near-surface deposits have been depleted and the trends in exploration have changed to subsurface mineral deposits.

Following are definitions of exploration activities shown in Tables 3.1-3.3.

Prospecting is defined as the search for mineral resources used by individuals on the basis of direct field observation of diagnostic rock or mineral assemblages. Historically, this activity is important as a first step in finding mineral prospects and mines. However, this step has been replaced by systematic exploration. In many countries, this term is used interchangeably with regional reconnaissance exploration.

Reconnaissance exploration is a preliminary exploration of large areas of unknown or little known geologic characteristics and mineral potential. It can be called *grass roots* exploration. Detailed follow-up explorations are required after discovery of target areas. In many countries, government agencies are involved in regional assessments of mineral potential by using this technique, either for land used policies or as a first step in exploration, such as aerial photography, and leave further detailed exploration of potential targets to the private sector.

Systematic exploration is the multi-organized search for mineral resources by mining companies or government agencies on the basis of the direct and indirect geologic, geophysical, and geochemical evidence, with help from empirical and genetic

Table 3.2 Discoveries of Non-ferrous Metal Mines in the US and Canada from 1951 to 1975 by Principal Exploration Methods

Discoveries of the **United States** metal mines 1951-1970					
Year of Discovery	Prospecting	Geologic Inference	Geophysical Anomaly	Geochemical Anomaly	Total Number
1951-1955	1	9	2	-	12
1956-1960	2	10	2	1	15
1961-1965	-	13	2	-	15
1966-1970	-	15	2	2	19
1951-1970	3	47	8	3	61

Discoveries of **Canada** metal mines 1951-1975					
Year of Discovery	Prospecting	Geologic Inference	Geophysical Anomaly	Geochemical Anomaly	Total Number
1951-1955	16	14	5	-	35
1956-1960	6	4	14	-	24
1961-1965	4	4	5	2	15
1966-1970	2	4	13	1	20
1971-1975	1	5	15	3	24
1951-1975	29	31	52	6	118

Source: Gocht et al.(1988, p.28), from original data gathered by Derry and Booth

Table 3.3 Gold Discoveries in the United States and Canada, 1970-1989

United States			
Year of Discovery	Prospecting	Systematic	Unknown
1970-1974	1	11	0
1975-1979	1	13	3
1980-1984	2	48	18
1985-1989	3	23	16
1970-1989	7	95	37

Canada			
Year of Discovery	Prospecting	Systematic	Unknown
1970-1974	4	1	0
1975-1979	5	3	3
1980-1984	7	23	11
1985-1989	5	29	21
1970-1989	21	56	35

Source: Eggert, Casey and Christnacht (1991) models of mineral occurrence and formation. Exploration activities range from regional assessment to pre-development geologic evaluations of the project (Gocht, et al. 1988, p.25-26).

3.2 General Exploration Methods for Gold

Geophysical magnetic and electromagnetic surveys may point out the promising target areas for gold deposits. Even though most gold deposits have no particular magnetic expression, magnetometer surveys can determine some rock types and detect structural complexity, such as fault and fold structures. Aerial photography can often delineate fractures and patterns of fractures favorable to gold occurrences. Geochemical exploration techniques include systematic chip sampling of outcrops and reverse-circulation drill cuttings, which can detect broad halos around ore bodies. Basic determination of gold in the samples of ores, concentrates, residues, slags, flue dusts and any nonmetallic gold-containing materials used by geologists or metallurgists are fire assay or gravimetric, volumetric, spectrophotometic, atomic absorption and emission spectrography, x-ray fluorescence and neutron activation.

3.3 Detailed Exploration Methods for Gold

This section will present more information about geologic, geophysical exploration and geochemical exploration in regard to gold exploration, and will examine how these methods have been developed and used in the different stages of exploration. The latter purpose might help clarify how the roles of technology (of exploration) improvements affected the discovery of mineral deposits. For additional comprehensive detail, see Gocht, et al. (1988, p.29-56).

Geologic exploration identifies the relationship between geologic settings and particular types of ore deposits. Basically, exploration begins with photographic interpretations, which are followed by geologic mapping and sampling of rocks and potential ore materials. With geologic mapping, the geologist will recognize and interpret the three-dimensional characteristics of rock bodies and structures. In addition, samples are studied microscopically to determine their mineral composition and texture. The geologic exploration should reveal basic mineral prospects, which are an estimate of the geometry, tonnage, and grade of potential mineral concentrations. This exploration will also lead to rejections of apparently barren areas (Gocht, et al., 1988, p.34).

In search of mineral deposits, geophysical exploration measures the differences in physical properties of rocks, minerals and ores. The exploration is useful to gain geologic information in large and remote areas because the survey is largely independent of topography and accessibility. The geophysical and geologic explorations complement each other on all scales. Airborne geophysics carried out either by airplane or helicopter works with photo-geologic interpretation and geologic mapping. Airborne geophysical surveys most commonly involves magnetic, electromagnetic and radioactivity surveys which can cover large areas rapidly and inexpensively per unit area. Furthermore, ground geophysical surveys, for example, electric, gravity and seismic, allow the application of a larger variety of geophysical methods and better solution. Combined with geologic mapping, the geophysical survey can display the correlation of geophysical signals from the subsurface with geologic surface information.

Remote sensing classifies the earth's surface by measurement of reflected or emitted electromagnetic radiation that helps geologists to understand the large area features and geologic formation and leads to discovery of the area's mineral potential. Remote sensing instruments are basically mounted on satellites that scan the earth's surface and measure reflected solar radiation or created radiation at a specific wavelength from 0.3 to 3m, which ranges from the ultraviolet through the visible-infrared to the micro-wave-radar spectrum. Remote sensing for commercial use began with the Landsat I by NASA in 1972, and the last Lansat IV and V were launched in 1984. Besides the U.S. satellites, there are also others: the French commercial satellite (SPOT), European

Space Agency (ERS-1), Canada (Radar Sat) and Japan (MOS-1), most of which were launched during the 1980s and early 1990s. Computer-aided image processing of the original electromagnetic data and data combination (algorithm) enhance geologic signatures and help to distinguish rock types or alteration zones by colors and pixels on the images (Gocht, et al. 1988, p.30-31).

Aerial photography provides the topographic and geologic basis for most exploration works for small areas of four square miles or less, while remote sensing covers very large areas of the earth's surface. This exploration method shows details of the earth's surface, such as topographic, geologic, and culture features. This method is an essential supplement for planning the logistics of exploration by pointing out areas of interest and by providing a view of access routes, camp sites, geochemical sample points, or lines of geophysical surveys (Gocht, et al. 1988, p.33).

The basic methods of geophysical exploration for mineral deposits are magnetic, electric, electromagnetic, and radiometric surveys, and for petroleum and natural gas are seismic and gravity surveys. Most geophysical measurements used in mineral exploration provide reliable results to depths of 100 meters at most (Gocht, et al., 1988, p.36).

Magnetic surveys measure the intensity of the earth's magnetic field. The presence of minerals and rocks which are magnetic or in which magnetism is induced by the earth's magnetic field, will locally deviate from the earth's field. The degree of induction is measured as the magnetic susceptibility of mineral or rocks containing the minerals, which are usually magnetite, ilmenite, hematite and pyrrhotite. Since the magnetic field obtained from the survey is a reflection of the underground rock types, magnetic surveys are useful for the detection of magnetite-bearing or pyrrhotite-bearing iron, nickel, or copper-lead-zinc deposits (Gocht, et al., 1988, p.37).

Electromagnetic surveys apply alternating currents to transmitting coils at or above the earth's surface to induce a magnetic field in electric conductors. The secondary current induced in the conductors causes a secondary magnetic field which, in turn, is measured in a detecting coil. The survey is commonly conducted by airborne surveys for rapid coverage of large areas, either by aircraft or helicopters, because the transmitting and detecting coils are easy to transport. An electromagnetic ground survey is a part of follow-up exploration because it gives more detail and better resolution than airborne surveys. Airborne electromagnetic surveys are usually combined with magnetic and radiometric surveys to give a fast and comprehensive geophysical structure of both ground and subsurface levels (Gocht, et al., 1988, p.40).

Geochemical exploration is seeking anomalous surface enrichments of elements, called primary and secondary dispersion halos, that can pinpoint potential ore deposits in the surface. Both the primary and secondary halos are sampled in geochemical exploration: rock chips from primary dispersion halos, partly weathered rock from primary and secondary halos, and soil, vegetation, stream water, stream sediment and heavy-mineral concentrate from secondary halos. First applied in Europe in the 1930s, geochemical exploration has been accepted as a rapid, sensitive and accurate analytical method and can be conducted on all scales of exploration. Analytical methods applied in geochemical exploration depend on the requirements of particular stages of exploration and on the availability of instruments. Analytical methods commonly are colorimetry, emission spectroscopy, atomic absorption spectrometry (AAS) and x-ray fluorescence (XRF) (Gocht, et al., 1988, p.45-47).

Chapter 4
GOLD PROCESSING AND RECOVERY

This chapter provides a brief background of gold processing and recovery processes that appear in the data sections of this study. It also summarizes the processing and recovery stages of gold mining. Milling and heap leaching are the common processing techniques used by gold companies in Nevada. The recovery processes can be carbon adsorption and zinc precipitation (Merrill-Crow). The rest of the chapter is devoted to how to treat the refractory ores, which may be a main source of future gold supply. Readers can find out more about the extractive metallurgy of gold from Yannopoulos (1990).

4.1 Milling of Amenable Gold Ores

The objective of milling amenable[1] gold ores is to extract the gold for the highest financial return. To recover the maximum amount of gold, the ore must be finely ground to liberate the gold particles for gravity separation and/or chemical extraction. A basic flowchart of the processing steps required to extract gold from ores is shown in Figure 4.1. Ore yields acceptable gold recovery (more than 88%) when theoretically ground to 60-75% at –200 mesh. The mineralogy of the gold ore dictates the required fineness of grinding for adequate gold liberation and economically optimum extraction recovery. There are three basic types of crushing and grinding circuits (Yannopoulas, p.56):

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[1] The word distinguishes the basic-extracted gold ores from refractory ores, which require extremely fine grinding and/or pretreatment before cyanidation.

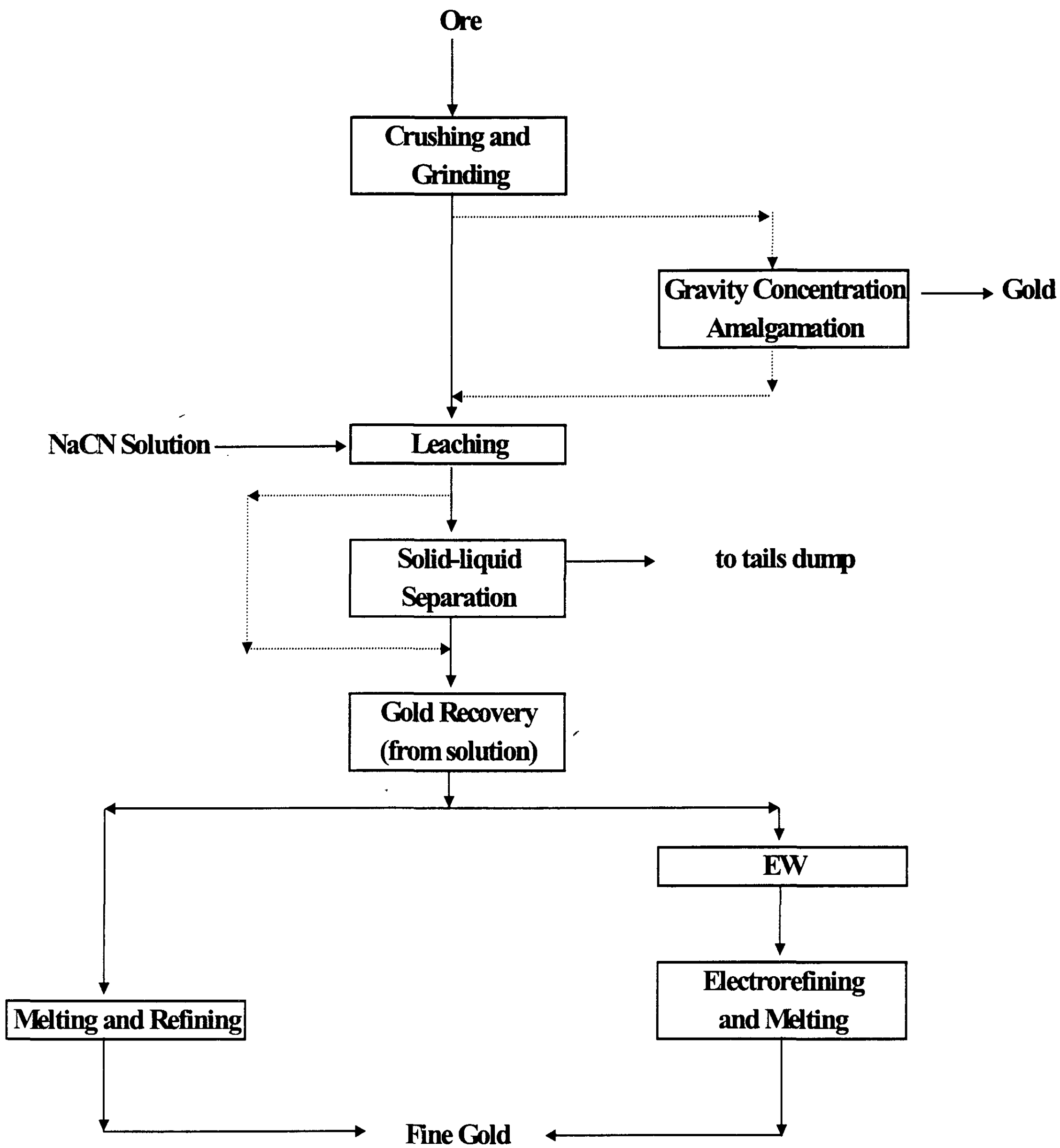

Figure 4.1 Basic Flowchart

Source: Yannopoulos (1990, p. 56)

1. Conventional three-stage closed-circuit crushing and rod-mill/ball-mill grinding.
2. Primary crushing and autogenous grinding.
3. Primary crushing with autogeneous mill followed by fine grinding in a ball mill.

Autogenous grinding or semi-autogeneous grinding (SAG) is the method that employs coarse lump ore as the grinding medium, while it is itself being ground. In practice, autogenous grinding has to be changed to semi-autogenous grinding (SAG) when the lack of adequately hard ore dictates the addition of large steel balls to maintain the required grinding rate at prescribed fineness (Yannopoulas, p.59). The benefit of autogenous grinding is lower capital costs, but it is energy intensive. Another application related to autogenous grinding is called autogenous grinding-ball milling-crushing or ABC. This ABC is applied when the hardness of ore or demand for mill capacity increases. It can significantly increase the ore throughput and reduce the grinding cost per ton of mill feed. Some gold can be recovered, if it was liberated (1mm to 0.03mm), from the underflow of cyclones or from the classifier by gravity concentration before cyanide leaching.

The early recovery of gold by gravity concentration has some very significant additional advantages beside gold itself (Yannopoulas, p.64):

1. Reduction of cyanidation plant's size
2. Recovery of coated gold grains that may resist or decelerate dissolution by cyanide
3. Savings in reagent consumption
4. No significant locking of gold behind the mill liners

Many devices are used for gravity concentration of the cyclone underflow. Stationary devices include plane tables with riffles, corduroy blankets, and spirals. Moving devices include jigs and shaking tables. The gravity concentrate has to be treated further by either amalgamation or intensive cyanidation. Stamp milling and amalgamation had been used to recover lode gold before the introduction of cyanide leaching in 1889. However, the use of amalgamation in gold mills has declined significantly in recent years because of concern about environmental problems.

Cyanide is added in the grinding mill to leach the pulverized gold ores. The gold cyanidation process has been universally used for gold-extraction practice since J. S. MacArthur and the brothers R. and W. Forrest patented the process in 1889. Low concentrations of cyanide for gold leaching are recommended because the leaching can lower cost (economic advantage) and the solution can be re-used several times without treatment (technical advantage).

4.2 Leaching of Low-grade Gold ores

Cyanide heap leaching of gold (and silver) ores is a recent development in response to the numerous discoveries of low-grade gold deposits during the late 1960s, mainly in the western United States. Besides that, the high price of precious metals also stimulated the development of low-cost cyanide leaching in massive scale. Carlin Gold Mining Company started a relatively small heap-leaching operation in Nevada in 1965.

Crushed ore is stacked on an impervious pad and sprinkled with cyanide solution to dissolve gold. For the heap leaching to be successful, the gold-bearing ore must be porous and contain fine-size clean gold particles. In addition, the ore, after having been crushed, must have good permeability to allow solution through the heap and to allow affordable consumption of cyanide. There are three basic leaching techniques: heap leaching, dump leaching, and vat leaching.

Heap leaching means leaching ores that have been mined, crushed, and transported on impervious pads for leaching by sprinkling or ponding, and perculation of the solution through the stack of the ore. Dump leaching means leaching dumps or accumulations of very low-grade ore or overburden, often without the use of prepared pads under them (Yannopoulos, p.120). The grade, tonnage and permeability of ore dictate whether to use a dump or heap leaching process.

By definition, vat leaching is flooding or submerging finely crushed ore in cyanide solution in large vats that can accommodate thousands of tons of ore. The objective of vat leaching is to reduce the leaching time, increasing extraction rate and gold content in the pregnant solution (solid-liquid solution). Vat leaching also has advantages over heap leaching under extreme conditions, such as desert environments, high altitude, high rainfall, and very low temperature. Patent applications were submitted in 1985 for the concept of "tank leaching." In practice, vat leaching does not give higher gold recovery than heap leaching because dry bulks of ore can occur within the vat. In addition, the ore for vat leaching must be crushed more finely than for heap leaching, which explains why vat leaching has not been as widely practiced as heap leaching.

4.3 Gold Recovery from Pregnant Solutions

The pregnant solutions produced from heap leaching are very dilute, containing 0.01 to 0.10oz./ton (0.34 to 3.40 mg/l) of gold. Gold is recovered from these solutions by either cementation with zinc (Merrill-Crowe) or by adsorption on activated carbon, followed by desorption and electrowinning of gold. The preferred method of recovering gold from pregnant solution is by adsorption on activated carbon followed by desorption and electrowinning. The pregnant solution percolates through a series of columns packed with activated carbon, which can adsorb up to 250 oz./ton of gold. Gold is stripped from the activated carbon, usually under high temperature and pressure, yielding another pregnant strip solution with 10 to 15 oz./ton of gold. The pregnant strip solution is the electrolyte flowing into electrowining cells where gold is deposited on cathodes.

Activated carbon is a highly porous material with special adsorptive properties. Gold recovery from solution by activated carbon is widely used in gold mills and heap leaching plants. The activated carbon systems used in gold recovery are indicated as follow (Yannopoulos, p.73):

1. Carbon in pulp (CIP) means the activated carbon is mixed with the leached slurry and adsorbs the gold solution. Professor T.G. Chapman of the University of Arizona developed the system in the late 1930s.
2. Carbon in leach (CIL) means the activated carbon is added to the ore slurry in the leaching tanks and adsorbs the gold from solution while cyanidation is leaching gold ores.
3. Carbon in columns means the activated carbon is packed in columns and adsorbs gold from clarified solutions as they percolate through.

Table 4.1 compares the strengths and weaknesses of both Merill-Crowe and carbon adsorption systems.

There are many techniques to elute (strip) gold from a loaded carbon. All elution techniques are selected mainly by two factors: scale of operation and local economic condition. The elution methods commonly used are chemical treatment, atmospheric Zandra process, alcohol stripping process, high-pressure stripping process, Anglo-American stripping process, and Micro gold desorption process. Readers who are interested in more detail can find information in Yannopoulos (1990, p.198-204). After the elution or stripping process, the gold solution is more concentrated and followed by basic recovering processes, either zinc cementation or electrowinning. Zinc cementation or Merrill-Crowe zinc process and the electrowinning will be examamined in the next two paragraphs.

In the Merrill-Crowe zinc process, the pregnant solution is pumped through Stellar Candle filters that have been precoated with diatomaceous earth for thorough removal of any suspended minute solids. The clarified solution is splashed through the plates of the under-vacuum Crowe tower to remove any dissolved oxygen. Zinc dust is added to the de-oxygenated solution as it flows to the precipitation filters. Pressure

Table 4.1 Comparisons of Merrill-Crowe Cementation and Carbon Adsorption

	Merrill-Crowe
Advantages	> Low labor costs for operation, maintenance
	> Precious-metal concentration in the leach solution has little effect on chemical requirements
	> Low capital expenditure for installation
	> Can handle large silver-to-gold ratios in pregnant solution
Disadvantages	> Pregnant solution needs pretreatment prior to precipitation
	> Process is sensitive to interfering ions
	Carbon Adsorption Systems
Advantages	> No pretreatment of pregnant solution required
	> Process handles slimy and carbonaceous ores
	> Very efficient recoveries, irrespective of incoming precious-metal concentration
	> Higher gold recovery (up to 99.9%) than Merrill-Crowe, since carbon systems get all the soluble values in every step
Disadvantage	> High silver grade in pregnant solution results in high carbon movement
	> Carbon is susceptible to fouling by calcium and magnesium salts
	> Carbon regeneration and stripping are labor intensive
	> Adsorption processes are more expensive to put on line than zinc-cementation operations
	> High tie-up of gold in inventory
	> Loss of gold with fine carbon
	> CIP sends more cyanide to the tailings pond and no recycling of solution

Source: Yannopoulos (1990, p.228)

Candle filters that are pre-coated with diatomaceous earth and a secondary coating of zinc dust are used to safeguard the precious precipitate (Yannopoulos, p.72).

Gold in cyanide solution was electrolytically deposited on lead foil cathodes that were removed periodically, melted into lead ingots, and cupelled to recover the gold. On the other hand, lead is recovered from the litharge (produced by cupellation) and rolled into foil to provide new cathodes. A high gold content in the cyanide electrolyte gives high electro-deposition efficiency and vice versa in low-grade solution.

Electrowinning of gold from pregnant solutions has two major advantages compared to gold precipitation by chemical agents. First, no chemical agents are added to the solution. Second, the electrowon gold is of high purity. Electrowinning of gold from cyanide solutions onto steel wool cathodes has become a very strong competitor of zinc precipitation and is a standard procedure of gold recovery for plants employing CIL or CIP. The gold-laden cathodes are washed, dried, and smelted or treated with acid to remove the excess of iron and then smelted. The iron slag with a high gold content is ground and has undergone gravity-enriched separation, and gravity tails are recycled into the mill. Figure 4.2 illustrates a general flowchart of recovery of gold by carbon adsorption.

4.4 Refractory Gold Ores

The definition of refractory ores is the problem ores that yield less than 80% gold recovery by cyanidation when "normally ground." Refractory gold ores are unoxidized (or partially oxidized) ores containing carboneceous materials, sulfides, and/or tellurides (Yannopolos, p.80). Gold associated with arsenic and bismuth is often partially soluble in cyanide solution. The refractory ores can be broadly distinguished by chemical or physical nature shown in Figure 4.3. The chemical refractoriness is relatively rare compared to preponderant (physical) refractoriness, which can be specified by

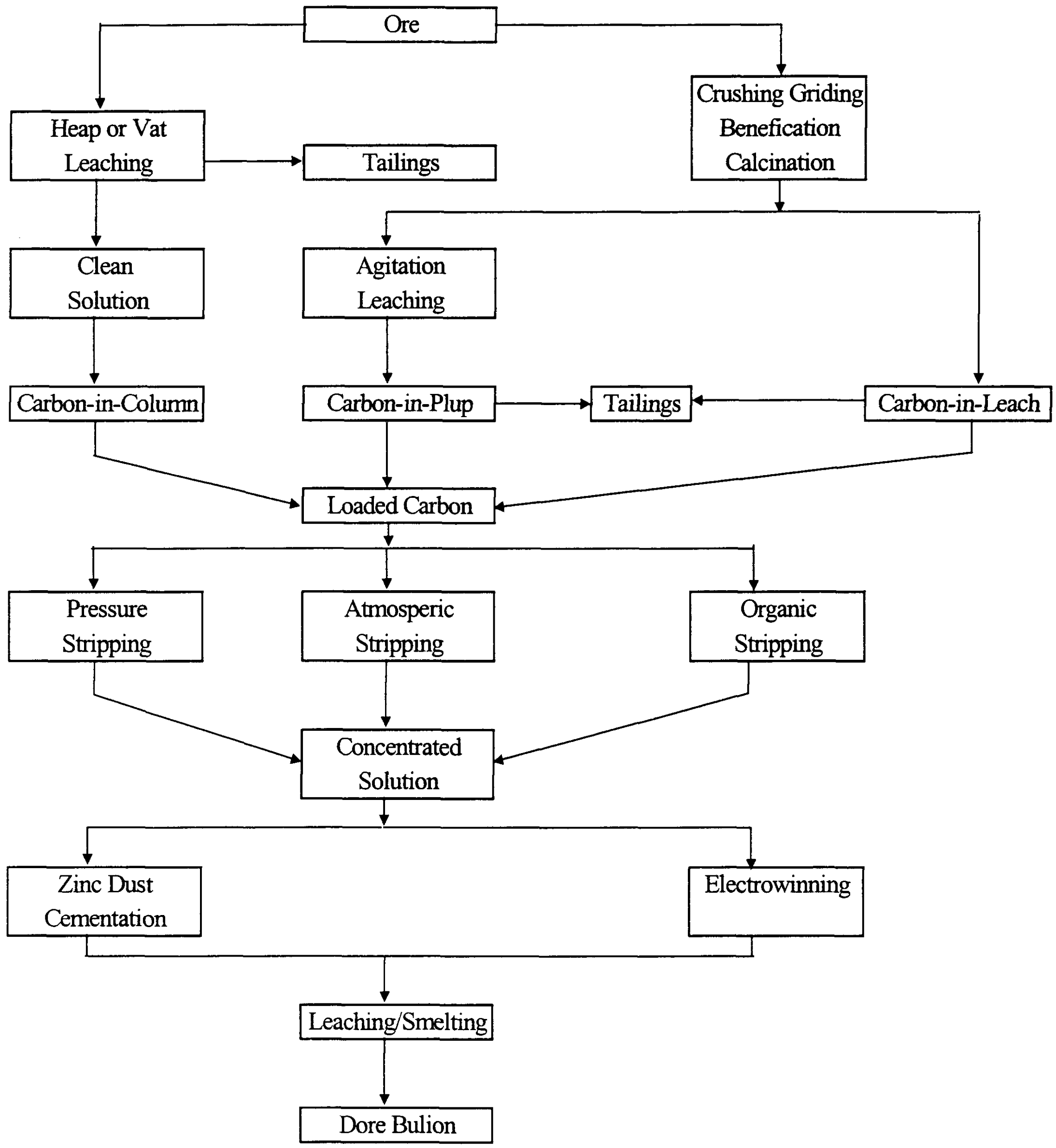

Figure 4.2 A General Flowchart of Recovery of Gold by Carbon Adsorption.

Source: Yannopoulos (1990, p. 195)

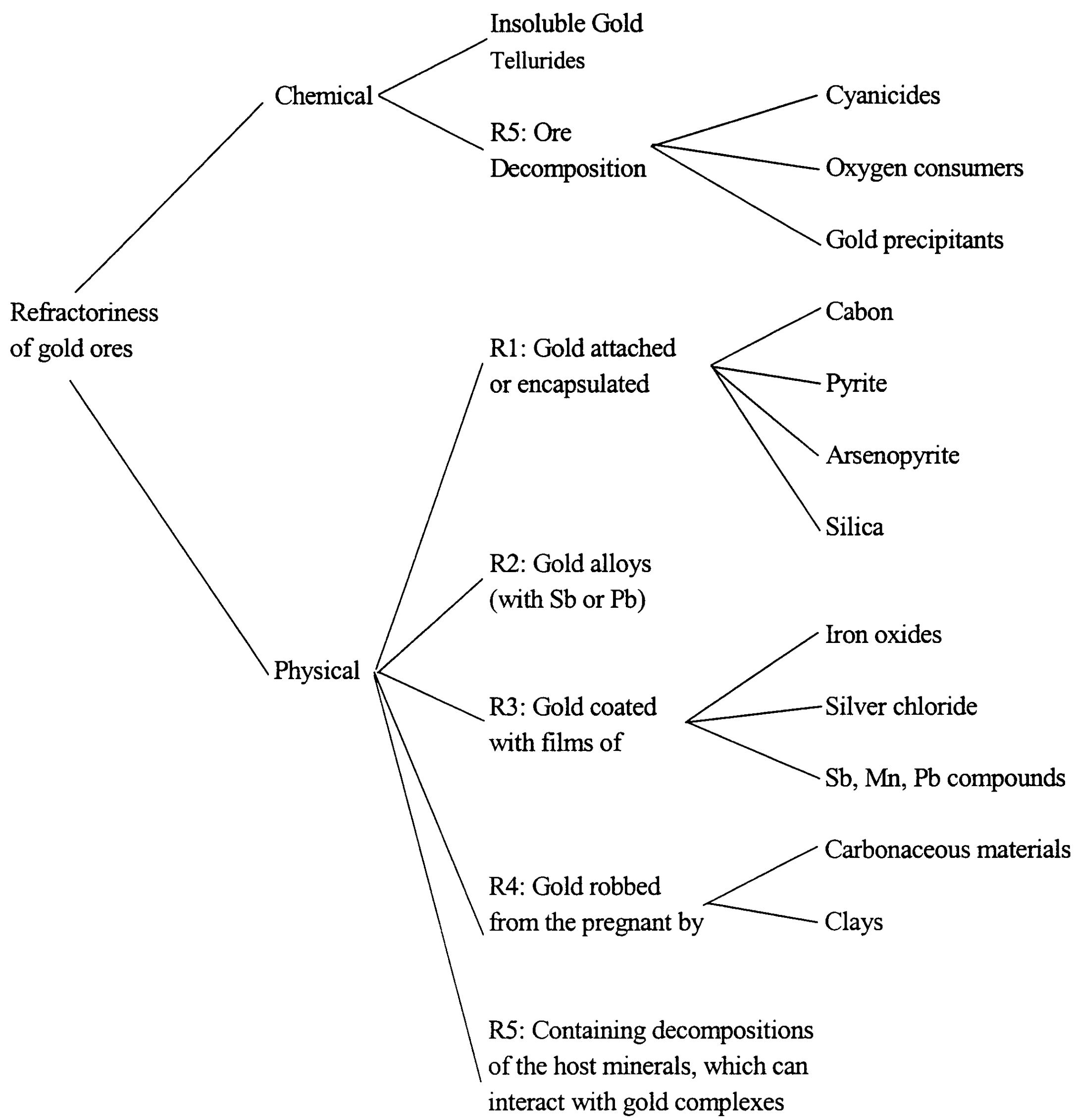

Figure 4.3 Classification of Refractory Gold Ores

Source: Yannopoulos (1990, p. 81)

microscopic mineralogy. Refractory ores were recognized early in 1968, for example, at the Carlin deposit, which are type R1, R4 and R5 (see Figure 4.3).

Most of the causes of refractoriness can be eliminated by an oxidation treatment before cyanidation. There are five potential treatments of refractory ores: roasting, high-pressure oxidation, low-pressure oxidation, chlorine oxidation, and biological oxidation. In addition, gravity separation and flotation often precede the treatment of a refractory ore.

Roasting (some call "calcination") or high temperature oxidation has the objective of liberating any gold particles encapsulated or attached in sulfides, arsenopyrites, or carbon, and of eliminating carboneceous material and any potential cyanicide. Roasting is probably the most widely used as a pretreatment process for gold refractory ores and concentrates. There are some conditions affecting the roasting process. For instance, temperature must be controlled to produce the optimal quality of pretreated ores. The composition and flow rate of the gaseous phase during roasting also have to be controlled to sustain the oxidation reactions at the optimal rate. There also have been some problems associated with the process. For example, contents of sulfur and arsenic oxides, tellurium, mercury contamination, and fine particulates are expected in the roaster gas, so additional gas-treatment installations are required to make the gas safe before being released to the atmosphere (Yannopolos, p.87).

The application of high-pressure oxidation is also known as autoclave oxidation technology. Oxidation conditions are crucial to the chemistry within the autoclave and can affect gold extraction. The oxidation of pyrite and arsenopyritic refractory ores has to be seriously tested in a laboratory autoclave and confirmed in a pilot pressure vessel. Important factors to optimize are the fineness of grinding, the pressure and temperature, density, pH of the slurry, and timing. A well-known application of autoclave technology was tested at the Mclaughin deposit (of Homestake Mining Company) in California. Many versions of high-pressure oxidation have been tested and considered in searching for the best treatments of the variety of refractory ores (Yannopolos, p.98-104).

Beside oxidation of sulfides (pyrite and arsenopyrite) by high-temperature and/or high-pressure methods, biological oxidation is an alternative choice. Bioleaching of refractory gold ores is a relatively new method, by which iron-sulfide minerals are degraded and the encapsulated gold grains are liberated and leachable by cyanide. The leaching microorganism used has been *Thiobacillus ferrooxidans* or *Thiobacillus thiooxidans*, which can be adapted to oxide iron and sulfur under acidic conditions. The microorganism can grow easily on pyritic and arsenopyritic ores at moderate temperatures but it is inactivated at temperatures higher than 40 degree Celsius, which is a drawback. There are other groups of bacteria, such as *Thermophilic* (name *Sulfolobus*), that might be able to grow at high temperature but so far have not been used on a commercial scale (Yanopolos, p.106).

Chemical oxidation was first applied to Carlin-type gold ores in the late 1960s by the U.S. Bureau of Mines (USBM) in Nevada. *Chlorine and sodium hypochlorites* were chosen as oxidation agents for the Carlin carbonaceous ores. The use of chlorine at Carlin proved to be very efficient, yielding 83-90% gold extractions from refractory ores. Another application enhancing the chemical oxidation is a double oxidation process, which blows air into agitated tanks. In addition, nitric acid, called nitrox process, can be used to oxidize sulfide and arsenosulfide minerals. Figure 4.4 summarizes the possible treatments of gold refractory ores (Yannopolos, p.108).

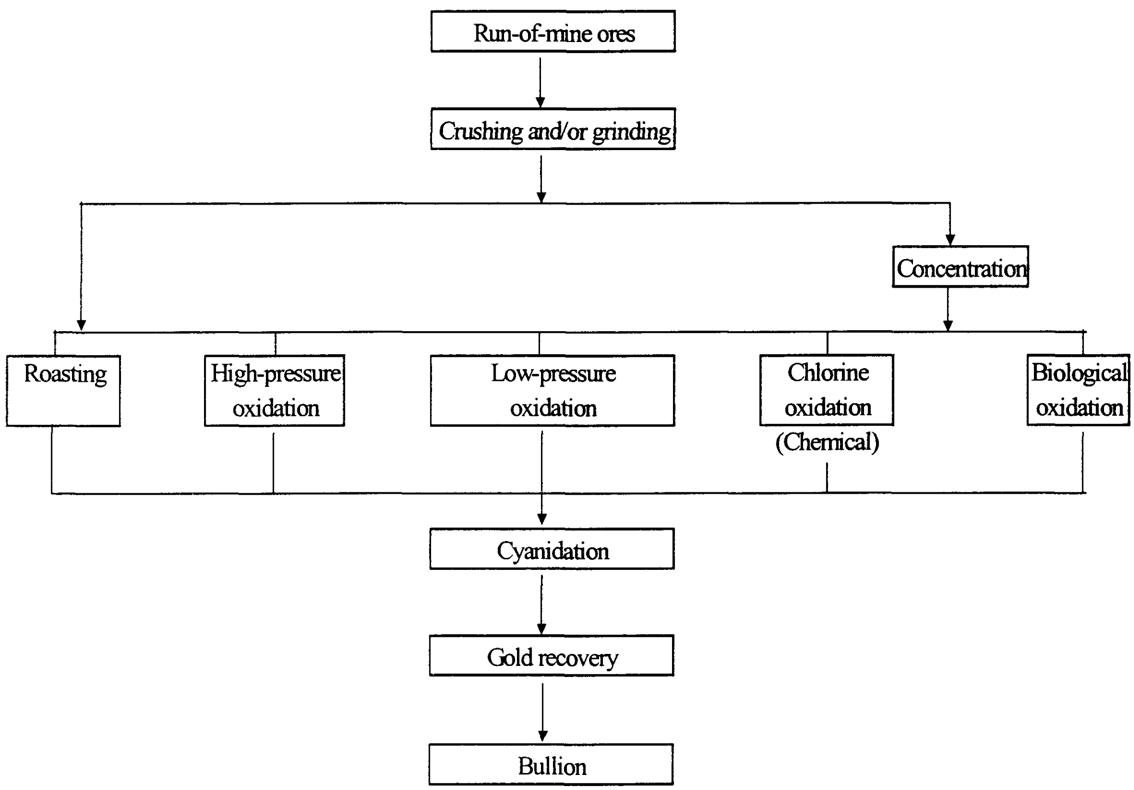

Figure 4.4 Potential Treatments of Gold Refractory Ores

Source: Yannopoulos (1990, p. 87)

Chapter 5
ANALYTICAL FRAMEWORK

This chapter has four sections. The first section describes Trocki's classification of development types used in her work. The second section indicates some points explaining why the classification needs to be adjusted for this thesis. The third section introduces the new classification using the geographic proximity and lead time factors (two-dimensional framework). The last section also shows how the adjusted Trocki classification fits into the two-dimensional framework.

5.1 Trocki's Classification of Development Types

Trocki's analytical framework basically draws upon the work of Adelman, et al. (1983) and Adelman (1970). Adelman believes that exploration is an economic activity, and is only a part of many interacting mineral supply processes. The mineral supply could be obtained from the interactions of the five separate processes that operate at the margin:[1]

1. Exploitation of currently opened mines (current operating margin).
2. Investment in the definition of more reserves in currently known deposits (intensive development margin); that, in other words, means a mining company can invest in the geological works to increase its reserves from known resources (probably deposits located at the same areas of a current operating mine or an old mine).

[1] Operating at the margin means operating at the minimum profit under which the company can survive.

3. Exploitation of the previously known and uneconomic deposits (extensive development margin); that means a mining company can develop and exploit the previously known and uneconomic deposits. The high mineral price is the factor to justify when the previously uneconomic deposits should be developed.
4. Searching for new deposits (exploration margin).
5. Investment in the new technology to lower costs of exploration, mining, and mineral processing (technology margin).

Exploration (shown in number 4 above) is one of the many different activities of mineral supply processes in Adelman's view.

The processes of the Adelman's framework might be considered as the vertical and horizontal movements on the McKelvey diagram (Figure 5.1). The vertical axis indicates the economic viability of a deposit; the horizontal axis indicates geological confidences of the deposit. To become a reserve base (also called demonstrated resources shown in the demonstrated column in the McKelvey diagram), developers must have an acceptable level of confidence in both economic and geological information (the movements on the axes). In other words, a reserve base is a portion of known ore bodies, which is well-defined and possible to exploit given current technology.

Trocki (1990, p.324) used Adelman's framework to design the classification of mine developments. The term "development type" used by Trocki means the sequence of events that lead to the opening of new mines. In her study, the development histories of the new mines in the iron and copper industries were classified into seven possible types:

1. Ancient mines: mines that were developed over deposits that have been mined since ancient times.
2. Previously mined: mines that resulted from the reexamination of abandoned mines, perhaps involving the application of a different ore deposit model and different mining technology.

Cumulative Production	Identified Resources			Undiscovered Resources	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical	Speculative
Economic	Reserves		Inferred Reserves		
Marginally Economic	Marginal Reserves		Inferred Marginal Reserves		
Sub Economic	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		
Other Resources	Includes non-conventional and low-grade materials				

Figure 5.1 The McKelvey Box

Sources: Based on US Geological Survey No. 1980, in Mineral Commodity Summaries, 1990, US Bureau of Mines

3. Expansion: mines that result from extensions or large expansions of existing mines, or mineralization that is developed as a by-product of other mining activity.
4. Previously known mineralization: areas where mineralization is noted but not drilled or defined until much later.
5. Previously known deposit: deposits that are drilled and known to exist but considered too low-grade or remote to develop until changes in mining, processing, or transportation technologies, prices, or politics occur.
6. Greenfield discovery: the classic discovery that results from relatively systematic exploration in a new region and discovery soon follows by development.
7. Related discovery: deposits that are discovered and developed soon after a new mineral province is identified by the disclosure of a major, greenfield discovery.

The connection of the development types defined above and Adelmen's framework of mineral supply processes are shown in Table 5.1.

From Trocki's opinions, mines that are classified as development type 1, 2, 4, and 5 are opened probably because exploration, mining, and processing costs decreased due to technological improvements, or the increase in gold price. On the other hand, type 6 and 7 mines are developed because of exploration investments. Finally, the type 3 mine is developed probably because current economic evaluation indicated the marginal profit.

5.2 Adjusting Trocki's Classification of Development Types

Three points in Trocki's classification do not fit this study and will be adjusted. First, Trocki's classification of development types was designed for copper and iron mines opened from the mid-1800s through the mid-1980s, quite a long period. On the other hand, this thesis considers gold mine openings in Nevada during the period 1970-

Table 5.1 Comparison of Development Types and the Adelman et al. Framework

Development Type	Adelman et al.'s Framework
1. Ancient mine	Intensive development and/or technology margin
2. Previously mined	Intensive development margin and/or technology margin
3. Known mineralization	Extensive development margin and/or technology margin
4. Known deposit	Extensive development margin and/or technology margin
5. Greenfield discovery	Exploration margin
6. Related discovery	Exploration margin
7. Extension	Current operating margin

Source: Trocki (1986, p. 39)

1999 because gold production has increased significantly since the late 1970s. The "Ancient mines" development type seems not to fit for the development of gold mines in Nevada. For this reason, Trocki's classification will be adjusted by omitting the "Ancient mines" development.

Second, many "Previously known mineralization" and "Previously known deposit" development types cannot be separated when they are applied to gold developments in Nevada. Most mining districts in Nevada have been known for existing mineralization. However, in order to classify the development type as a "Previously known deposit," more information about the history of discovery is needed. Some gold mines do not have a clear definition of the discovery. In the past, the discovery can represent either uncovering of mineralization areas or mineral deposits depending on exploration methods (drilling) used. Recently, the word "discovery" has been widely used when a drill hole intersects a mineral zone, which Trocki also used. To avoid this problem, "Previously known mineralization" and "Previously known deposits" development types are grouped together and represented as an old mineral supply source.

Third, there are few gold mine openings in Nevada that might be categorized as the "Expansion" development type based on Trocki's definition. However, these mines did not truly "expand" their operations. They changed their operations from copper extraction to gold extraction when copper prices lowered, such as at Copper Canyon. In addition, they usually produced both main and co-products at the same time and gold production from these mines was insignificant. This development type will be omitted to reduce any confusion.

Finally, "related discovery" in Trocki's definition will include any discovery made by brownfield exploration, which is mainly referred to exploration that focuses on or near exiting properties.

The adjustment aims to condense the categories and not change the definitions of remaining development types. The meanings of development types used in this thesis will mostly remain the same as Trocki's definitions. In summary, the adjusted Trocki's classification of development types can be roughly categorized into four types:

1. Previously mined
2. Previously known mineralization or deposit
3. Greenfield
4. Related discovery.

In further discussion of the development histories of gold mines and classification, the "previously mined" and the "previous known mineralization or deposit" will be considered together and called the "old field." Old field mines all represent the revaluation of ore bodies or deposits that become economically attractive as technologies or market conditions changes. On the other hand, "greenfield discovery" and "related discovery" can be grouped together to represent the new discoveries that are promptly developed. The latter group will be called the "new field."

5.3 Classification by Geographic Proximity and Lead Time

Trocki's method of classification by development type was designed to distinguish among such cases as the prompt development of the new discovery ("new field"), the revaluation and development of the previous discovery, or reopening an old mine ("old field"). As mentioned above, the method can be difficult for classifiers to maintain a consistency of classification, especially for mines with a long history of development and intermittent production or with deposits close to each other. For instance, Trocki's definitions of development types sometimes can fit into more than one type when applied to a studied mine. For this reason, using Trocki's classification of mine openings can be confusing.

The objective of classification is to answer two questions. First, where did the new discovery of mineral deposit come from? Second, did a mine open from a prompt development after discovery or from revaluation of the known mineralization or deposits? The answer to the first question represents the location factor, which can distinguish the "greenfield discovery" from "related discovery." On the other hand, the answer to the second question will capture the timing factor, which can differentiate the "new field" from the "old field" category.

In order to have a clear and better classification, this study will use a new method called two-dimensional classification to classify the development histories of the gold mines in Nevada. The two-dimensional classification is designed to make the classification of development types clear and consistent but still allow comparisons with Trocki's classification.

The two-dimensional scheme is based on two important factors of mine openings: *geographic proximity and timing*. The geographic proximity is defined by the distance of a new discovery's location, which will become a new mine, from any operating mine or any mining activity when the discovery happens. The base distance is set at a 20 mile radius. A discovery or a new mine opening which is less than a 20 mile radius will be categorized as a "close" proximity. A new mine opening of more than a 20 mile radius will be categorized as a "distant" or "far" proximity.

The timing or lead time is defined by the period of time in years between the year in which the deposit is discovered to the year of starting production. The lead time will be set in two intervals: *less than or equal to 5 years and more than 5 years*. A lead time of up to 5 years will be classified as a "new field" of gold deposits because the timing indicates prompt development. A lead time of more than 5 years will be classified as an "old field" gold deposit. The following section expands on these base values. Figure 5.2 illustrates the two-dimensional classification, which comprises three sections.

5.4 Setting the Base Values of Geographic Proximity and Lead time

The distance of geographic proximity can indicate how gold companies approach their exploration's objectives and search for gold deposits, while lead time can be related

		Timing or Lead Time (Discovery-Mining Period)	
		Less Than or Equal 5 Years	More Than 5 Years
		"new field"	"old field"
Geographic Proximity to Mining	20 miles or closer	**Section A** (Related discovery)	**Section C** (Previously mined or Previously known deposits or Previously known mineralization)
	more than 20 miles (Distant/Far)	**Section B** (Greenfield discovery)	

Figure 5.2 Two-dimensional Classification

to mining methods and the variety of geological settings of the gold deposits. One might question why the geographic proximity is set at the 20-mile radius and the lead time at 5 years.

In Nevada, there are three exceptional gold mineralized trends that have produced a significant amount of gold production since Carlin mine's production started in 1965. They are Carlin, Getchell, and Cortez trends.

The Carlin Trend, also known as the "Carlin Gold Belt," includes a group of gold deposits that since 1988 have extended for a distance about 25 miles.[2] Deposits in the trend are the locus of the Bootstrap, Lynn, and Carlin windows in the Robert Mountain trust located both in Elko and Eureka counties. Dee mine is located at the northwestern end of the trend in Elko county and, in the opposite direction, Gold Quarry mine is located at the southeastern end of the trend in Eureka county. There are seven original mines on the trend between these two mines: Bootstrap, Goldstrike, Post, Genesis, Blue Star, Maggie Creek, and Carlin.

Mines in the Getchell and Cortez Trends are even further apart, about 25-30 miles from gold mine to gold mine located at both ends of the trends. Getchell Trend has Chimney Creek and Pinson mines at the both ends of the trend and there are Getchell and Pinson mines on the trend. Finally, the Cortez Trend extends southeasterly from Gold Acres; it is one of the first disseminated gold deposits discovered, and it extends to the Tonkin Springs mine. There are also Cortez, Horse Canyon, Toiyabe, and Robertson mines along the trend.

From the geological distances of these three trends, the based value of geographic proximity is designed to be 20 miles to ensure that the "related discovery" category can be reasonably separated from "greenfield discovery." Within 20 miles of mining areas in Nevada, any "related discovery" should have a geological relationship to the existing deposits or any previous greenfield discovery at some level of geological confidence.

[2] New mines have been opened on the Carlin Trend and in 1999 a group of gold deposits extended for about 45-50 miles.

Furthermore, this study will conduct a sensitivity analysis of the proximity's distances varied from the based value.

The timing or lead time, that is, the time between discovery and production, varies according to mineral deposits, infrastructure for development, bureaucratic policies, mining and processing methods, scale of project, market opportunity, obtaining finance, and company experience (White, 1997, p.263).

White (1997) studied gold discovery in Australia and indicated that medium to large gold discoveries in Australia have lead times ranging from 4-5 years, down to as little as 9 months for small deposits. These statistics are from 16 gold deposits and 11 copper gold deposits discovered between 1952-1991. In addition, typical lead times are 5 to 15 years for most mineral deposits in Australia or even longer in some cases (White, 1997).

Ivosevic (1984, p.121-149) collected the statistical data from 61 bulk-mineable gold and silver deposits of over one million short tons, which probably includes all of the most important precious metals deposits in North and Central America at that time. Included are some deposits which were recently depleted, temporarily abandoned, or are awaiting reactivation. The 61 deposits can be roughly classified into 3 groups of geologic classes: Volcanogenic,[3] Carlin-type, and Sedimentary-rock hosted deposits. He also collected data on general operations, reserves, mining, metallurgical processing, and costs in developing these deposits. Lead-time required to develop is an average of 9 years from 21 sample deposits and, from these samples, the lead time ranges from 4-19 years.

From the information above, the based value for the lead time is set at 5 years. If a new opening mine can develop within a 5-year period, it can be said that this mine is promptly developed after discovery or that it can be reopened in that time from an old mine. The second possibility is most likely to happen with underground gold mines,

[3] Volcanogenic deposit can be subdivided into Cenozoic, Mesozoic, and Subvolcanic deposits. See Ivosevic's handbook for details.

which have had a less significant impact on gold production in Nevada during the period of study. The main source of gold supply comes from bulk-mineable deposits[4], which basically requires open pit mining, and generally needs less development time than underground mining. In addition, many new mine openings from the revaluation of the previously known mineralization or deposits have taken more than 5 years to become an operating mine. Factors such as basic infrastructure, mine development, or operating budgets may contribute to a prolong lead-time. For these reasons, the 5-year lead time will be the base value of the study. Sensitivity study will be conducted by varying lead time.

In summary, 5-year and 20-mile based values are necessarily pre-designed for the two-dimensional classification. These values are designed based on the mining and geological information discussed above. It is possible that some new mine openings developed right after discovery might take more than 5 years to start producing. This study has to assume that the number of exceptional mine openings and its production is insignificant.

5.5 The Relationship of Two-dimensional Classification and the Adjusted Trocki's Classification

The adjusted Trocki's classification of development types can be fitted in the four quadrants of the two-dimensional classification as follows:

Section A, in which lead time is less than or equal to 5 years and at a "close" proximity can obviously represent the "related discovery" type of development of the mine opening (new field).

[4] The bulk minable deposits cover all other types of a large tonnage, low grade deposits including disseminated gold or silver deposits. Ivosevic explains more about how one might misuse the word "disseminated." (p.5)

Section B, in which lead time is less than or equal to 5 years and at a "far" proximity, can represent the "greenfield discovery" type (new field).

Section C, in which lead time is more than 5 years and in a "close" or "far" proximity, can represent the "previously mined," "previously known deposit," and "previously known mineralization" type (old field).

The studied mines will be classified into A, B, and C sections. The number of mines and the accumulated production in each section will be summarized to indicate their effects on the mineral supply and the history of development in Nevada. Please note that each section indicated above is interchangeable with the development types (see Figure 5.2).

Factors such as technological changes and gold price will be briefly examined in each section using qualitative analysis to illustrate how these factors affect the number of mine openings and production. The study will look at the different periods of time as well.

5.6 Database Format and Data Sources

Data for this study will be divided into five sections: Production, Location and Ownership, Mining and Geology, and Discovery and Reserve. These data are shown in Appendix B (B-1 to B-4).

The Production Table in Appendix B (B-1) lists the 1970-1999 gold production of operating mines in alphabetical order. Not every operating mine has production records, so the annual total identified production will be less than the annual total state (Nevada) production. On the other hand, in many years the total annual identified production has been exceeded by the annual total state production because some local refining and smelting plants probably processed ores from out of state. However, most differentials were not significant. In addition, in some mines annual production has to be an averaged production, because the actual annual production is withheld as confidential.

The mine production data during the 1970-1990 period is mainly obtained from *Mineral Yearbooks* and the annual reports summarized for that particular mineral commodity (U.S. Bureau of Mines [later USGS], various years). Many publications from Minobras Mining Services and the *Nevada Mineral Industry* (Nevada Bureau of Mines and Geology, various years) are also essential sources. Production records for 1985 can be found in *U.S. Gold Production* (Metal Economics Group, 1986). During the 1970-1990 period, the production data of some mines were withheld for confidential purposes in the *Mineral Yearbooks* and reported only in Nevada county production. However, from cross checking with other sources and company's reports, the production data can be obtained by estimating from the expected annual production of these mines or the averaged annual production. The estimation of production happens only for a few mines, and annual production data were generally obtainable.

During the 1990-1999 period, the annual production of every active mine was recorded fairly thoroughly in *Major Mines of Nevada* (Nevada Bureau of Mines and Geology, various years), and *Nevada Mineral Industry* as well. Mine production data can also be obtained from various mining directories, such as *American Mining Handbook*, *Randol Mining Directory* (Randol International Ltd., various years), *Mining Section of Energy Yearbooks* (TIME Publishing, various years), and *Western Mining Directory*. In addition to these directories, company annual reports or forms submitted to the Securities and Exchange Commission, such as form 10-K, can be good and reliable sources. Annual mine production from different sources have been recorded and checked to ensure precision. By cross checking data, the results were corroborated among sources.

A few problems are associated with the collection of data. The first problem, mine production, comes from the accumulated annual production of a company operating many mines, which cannot distinguish production among those mines, such as Newmont Mining Corporation. Second, some small and intermittent producers have not recorded their production consistently. Finally, the reports of gold production in the *Mineral Yearbooks* and other publications by the USGS have changed from ounces to kilograms.

All production has been converted to ounces for consistency. The second and the third problems have insignificant impacts on production. On the other hand, the first problem may change the results of this study. To overcome the problem, mine production has been carefully collected and rechecked with mill production reported annually in the 10-K form or company report.

The Location and Ownership Table in Appendix B (B-2) illustrates locations, districts, counties, operators, and owners of mines. This table indicates only the last or present operators and owners. The data are obtained mostly from *Major Mines in Nevada* and *Nevada Mineral Industry*. Many directories and handbooks indicated above are also useful and can be used as secondary sources. The only problem is that operators and owners sometimes change very quickly.

The Mining and Geological Table (B-3) shows mining and geology information. This table indicates current mining methods, classification of gold deposits, ore type, and processing methods. The classification of gold deposits can be classified into two groups: primary gold deposit, and by- or co-product of the primary metal deposit. The primary lode gold deposit[5] can be roughly subdivided into cavity fillings, replacements, and disseminated deposits, which are described as follows (Ivosevic, 1984):

The cavity-fillings deposit results from open space deposition of hydrothermal solutions that are localized by faults, folds, and shearing. This lode deposit can be veins, saddle reefs, or breccia types, which are basically mined by underground mining. This lode deposit can also be associated with silver or other metals.

In the replacement deposit, earlier formed minerals are replaced with ore minerals by substitution, which generally happens to carbonate rocks such as limestones and dolomites. Statiform or bedded deposits in limestones and dolomites, vertical pipes, or chimney-like orebodies replacing carbonate rocks are characteristics of this type of deposit.

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[5] Gold deposits from placer will not be studied because it is not a primary source of production in Nevada.

The last type of deposit is the disseminated deposit. Gold mineralization is finely dispersed through host rocks as submicroscopic to microscopic colloidal particles.[6] Very fine-grained gold is associated with jasperoids in limestones and dolomites. Ore bodies are generally irregular and lack defined boundaries. The disseminated deposits basically are of a lower grade than cavity-fillings deposits, but they are of a much larger size, allowing economical open pit mining. The Carlin deposit in Nevada (1965) was the first deposit of this type to be mined in the United States. In this study, the disseminated term will be applied to all bulk and low-grade mineral deposits, even though it might not be correctly applicable to some deposits.

Many geologists have a different geologic classification for gold deposits. For instance, Ivosevic (1984) classifies gold and silver deposits into four groups: Carlin-type, Back arc volcanogenic silver or gold, stock works or tactite and conventional vein, and replacement deposits. Even though the classification can vary, the definitions are still based on the same principles of geologic settings of gold deposits, and the classification above is believed to be concise and reasonable. The classification of each mine is based on the information in a specific time period, which might not be correct in every mine, especially when time has passed and the mine possibly processes new types of ore deposits.

The processing methods used by operating mines depend on ore and deposit types. The processing methods were introduced in chapter 4.

The data in Table B-3 are obtained from many Minobras publications. In addition, the processing methods are found in many directories and handbooks, including the *Nevada Mineral Industry*.

The Discovery and Reserve Table (B-4) is an important table. It indicates discovery years, years of production start-up and periods of operation, ore grades, and reserves. The year of discovery is hard to obtain and arguable, because the definition of

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[6] Ivosevic (1984) indicates that disseminated term is accurately applied to the disseminated (micro size: 0.001 mm) gold deposits of the Carlin type.

discovery can vary from person to person and from time to time. For example, Cranstone (1988, p.286) states that "A discovery is a mineral deposit sufficiently attractive to have warranted the expenditure necessary to establish its tonnage and grade. Discovery date is considered to be the year in which a drill hole intersected a mineral zone that was recognized within a relatively short time as being part of a mineral deposit so that its tonnage and grade were established." McKenzie and Woodall (1986), Rose and Eggert (1988), and Trocki (1990) also use this definition. However, it is difficult to ensure that all deposits discovered and discovery dates have been recorded following the same definition. In addition, the stages of exploration and methods might have been conducted differently due to exploration targets and strategies, which could lead to inconsistency in discovery records.

Even though many data sources did not clearly state the definition of discovery date or methods, it might not make much difference whether the discovery is announced this year or next year. It will be an insignificant time line compared to following development and operating years. Furthermore, most discoveries during the past two decades have been found by systematic exploration, essentially a drilling method. Thus it must be noted that the need for the discovery definition and recorded dates are less important.

The ore grade and reserve data have constantly changed due to gold prices and stripping ratio changes. In addition, the earlier in the exploration process, the more likely resources will be reported. As exploration advances, more of the resources will be transferred to the reserve.[7] That is why the data in the table indicate the recorded years followed reserve data. They can be used only for references in a specific time. The data shown in the table are obtained from many Minobras publications, articles in SME proceedings and books, USGS *Mineral Yearbooks,* and Nevada Bureau of Mines' publications.

[7] Comments from David Wilburn on another possibility of reserve changes.

CHAPTER 6
ANALYSIS OF NEW GOLD MINE OPENINGS

Nearly one hundred new mines opened in Nevada between 1970 and 1999. Only two major mines, Carlin and Cortez, opened before 1970. In the study here, all new gold mine openings including Carlin and Cortez, are classified into three sections using a two-dimensional scheme. As mentioned in Chapter 5, each section in the two-dimensional classification represents a different development type. Here we will use the name of the development types-"related discovery," "greenfield discovery," and "previously mined, or previously known deposits or mineralization,"-instead of the designations A, B, and C.

To add time as a factor, new mine openings and production are classified into six 5-year periods.[1] The role of development types related to gold supply over time will be examined.

The analysis consists of six sections. Section 6.1 summarizes the results of the two-dimensional classification and examines how the different development types affected gold production in Nevada from 1979 through 1999.

Section 6.2 sheds some light on the types of gold deposits that were discovered and became sources of gold supply, and how those deposits were related to processing methods.

Section 6.3 examines the evolution of new gold mine openings over time and the factors that might affect the number of mine openings in each time frame. In addition, new mine openings will be classified by development type and a determination made of how long it took to bring the mines into production.

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[1] The first period is 1970-1974 and the last period is 1995-1999.

Section 6.4 examines why the results of this study differ from Trocki's, whose study dealt with iron and copper mine openings over a longer time frame.

Section 6.5 presents the results of sensitivity analysis when proximity and lead time are changed from base values-20 miles radius for proximity and 5 years for lead time. Included are changes in production and mine openings for each development type.

Section 6.6 plots mine locations using a grid system, and incorporates levels of production and start-up years. Mine areas that have significant production and the locations of new mines opened recently are indicated. Such information could be useful in making exploration decisions.

6.1 Summary of the Two-dimensional Classification of New Gold Mine Openings

Using the two-dimensional framework, the number of mines and accumulated production in each section are shown in Table 6.1. Mine openings during the 1970-1999 totally 106, of which 71 were developed from "new field" discoveries ("related" and "greenfield" discoveries), and 35 mines were developed from "old field" sources ("previously mined" and "previously known deposit or mineralization.")

Total production from 106 mines was about 91.7 million ounces, of which 70 million, or 76 percent, was produced from "new field" and only 22 million, or 24 percent, from "old field." Gold production from "new field" is almost three times that of "old field" production. The list of mines and production in each development type are shown in Appendix C.

The important results of the two-dimensional classification are summarized as follows:

1. The development histories of gold mine openings in Nevada has shown that past production (76%) mainly came from the prompt development or "new field" category (less than 5-year lead time, specifically an average of 3 years) mostly from the "related discovery" development type. On the other hand,

Table 6.1 Summary of Results Using Two-Dimensional Classification

		Timing (Lead Time)		
		less than or equal to 5 years (new field)	more than 5 years (old field)	
Geographic Proximity to Mining	20 miles or closer	(related discovery) 46 54,796,746	(previously mined or previously known deposit or previously known mineralization) 35 21,709,200	No.of Mines Production (ounces)
				No.of Mines Production (ounces)
	more than 20 miles	(greenfield discovery) 25 15,238,114		No.of Mines Production (ounces)
	Total Mines	71	35	106
	Total Production (ounces)	70,034,860	21,709,200	
	Total Grand Production (ounces)		91,744,060	

		Timing (Lead Time)		
		less than or equal to 5 years (new field)	more than 5 years (old field)	
Geographic Proximity to Mining	20 miles or closer	43.40 59.73		% of Total Mines % of Total Production
			33.02 23.66	% of Total Mines % of Total Production
	more than 20 miles	23.58 16.61		% of Total Mines % of Total Production
		76.34	23.66	% of Total Production

"greenfield discovery" partly contributed to the total gold production, which was less than 20 percent of total production.

2. The results *do not* support the previous hypothesis that the mine openings mostly (more than 50 percent of the past-verified total production) result from the reevaluation of mineralization or ore bodies that had been known for years ("old field" category). Only 24 percent of total production came from "old field" category.
3. The results differ from Trocki's conclusions that much (commodity) mineral supply came from the revaluation of old or previously known mineral deposits, not from the prompt discoveries. The history of gold production in Nevada was not applied to Trocki's analysis. Almost 80 percent of the production obviously came from prompt development after discoveries, probably to take advantage of the upper cycle of high gold prices. Why the results differ from Trocki's will be discussed in section 6.4.
4. Finally, "greenfield discoveries" surprisingly produced less than 20 percent of total production. However, a greenfield exploration cannot be ignored. Even though the exploration fails to uncover new, high-grade deposits, the knowledge of geological structures and promising exploration areas can increase over time and also increase the chances of successful future discoveries. In other words, exploration can increase "old field" sources of gold supply. Besides that, disseminated gold deposits from "related discovery" have been less available lately (see Figure 6.11 and 6.12). The trend of increasing production from "greenfield discovery" can be seen during the past 5 years because "old field" sources of gold reserves are depleting. Furthermore, the study also indicates that disseminated deposits may be found by greenfield exploration, as observed from the increasing portion of disseminated production from "greenfield discovery" development.

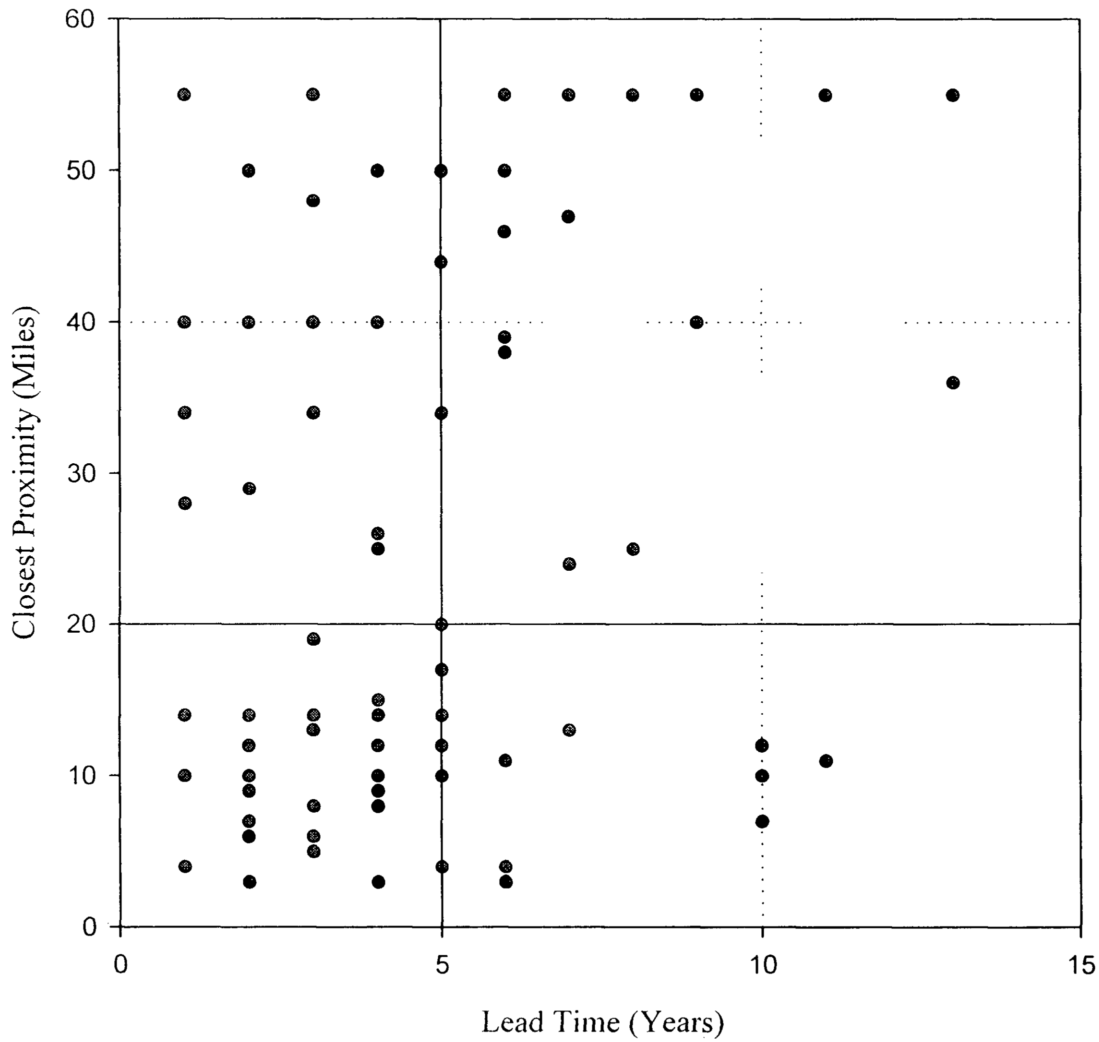

Figure 6.1 Lead Time and Proximity of New Mine Openings

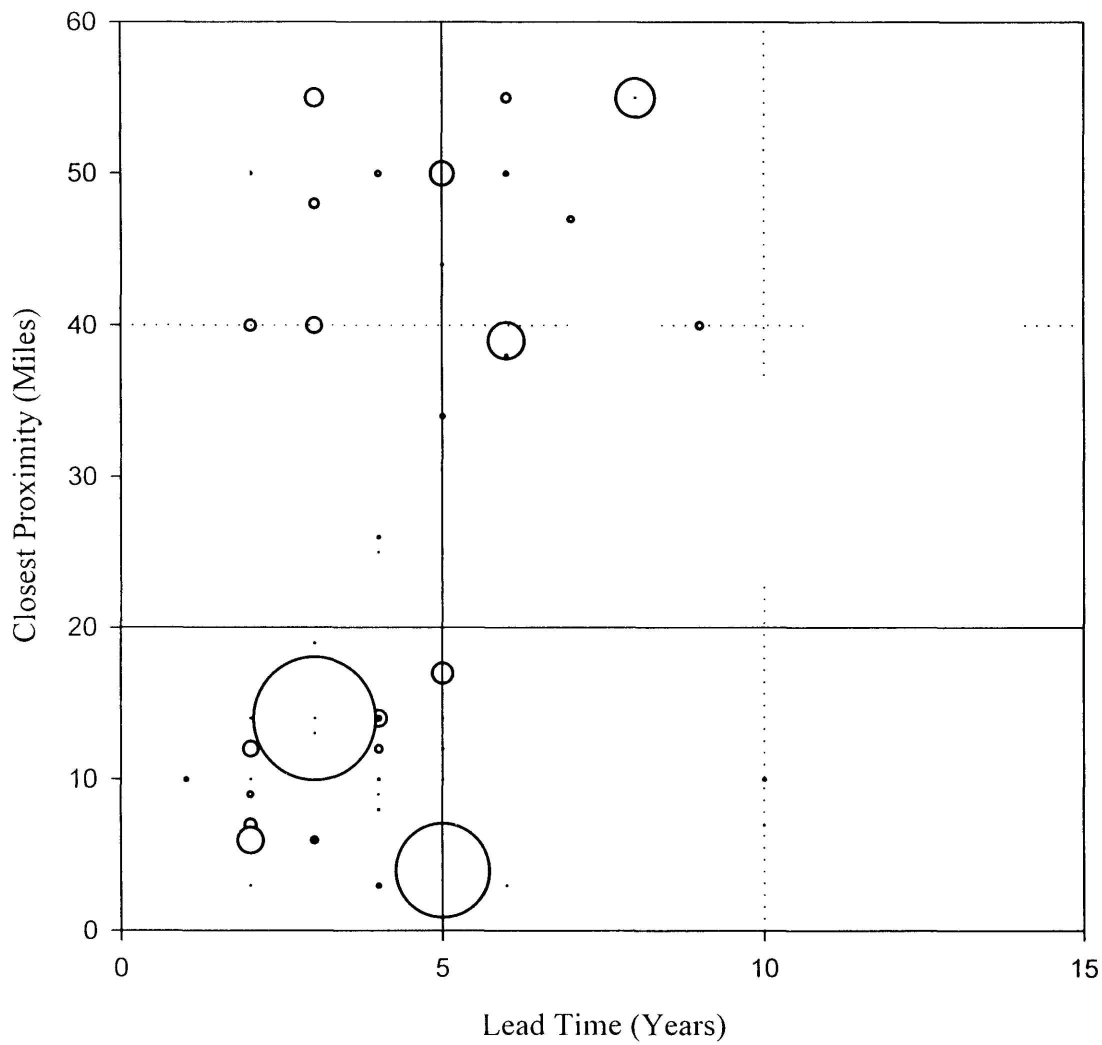

Figure 6.2 Lead Time and Proximity of New Mine Openings (includes production shown by size of the circle)

Figure 6.1 is a scatter graph of mine openings plotted by using the closest proximity and the lead time. This graph shows the mine openings from "related discovery" (at the southwest quadrant[2] of the graph) are relatively clustered compared with other development types. Some mine openings, especially in "related discovery," have the same values in both proximity and lead time, so one spot in this graph might represent more than one mine opening. The size of the circle in Figure 6.2 represents the magnitude of total mine production. Similarly, Figure 6.2 indicates a significant production from "related discovery" shown by the largest circle. The second largest production came from "old field."

6.2 Types of Gold Deposits and Processing Methods Used in Each Development Type

Figure 6.3 indicates total production classified by different deposit types and processing methods used in development types. Three deposit types are cavity filling, replacement, and disseminated. The processing methods are roughly classified into two groups: heap leaching and other processing methods. The other processing methods can be flotation, milling, or combining methods.[3]

The "new field" category, which comprises "related discovery" and "greenfield discovery" development types in the two-dimensional classification, indicates two important results of gold mining and processing methods.

First, the disseminated gold deposits are the main sources of gold production for both "greenfield" and "related discovery" development types, especially in "related discovery." Disseminated gold production in "related discovery" alone contributed almost 40 million ounces (more than 70% of total production) in this development type.

[2] Vertical and horizontal lines are drawn at 5 years lead time and 20 miles proximity, respectively. By the definition, "related discovery" will be at the southwest quadrant.

[3] The combining methods can be heap leaching and flotation, or milling.

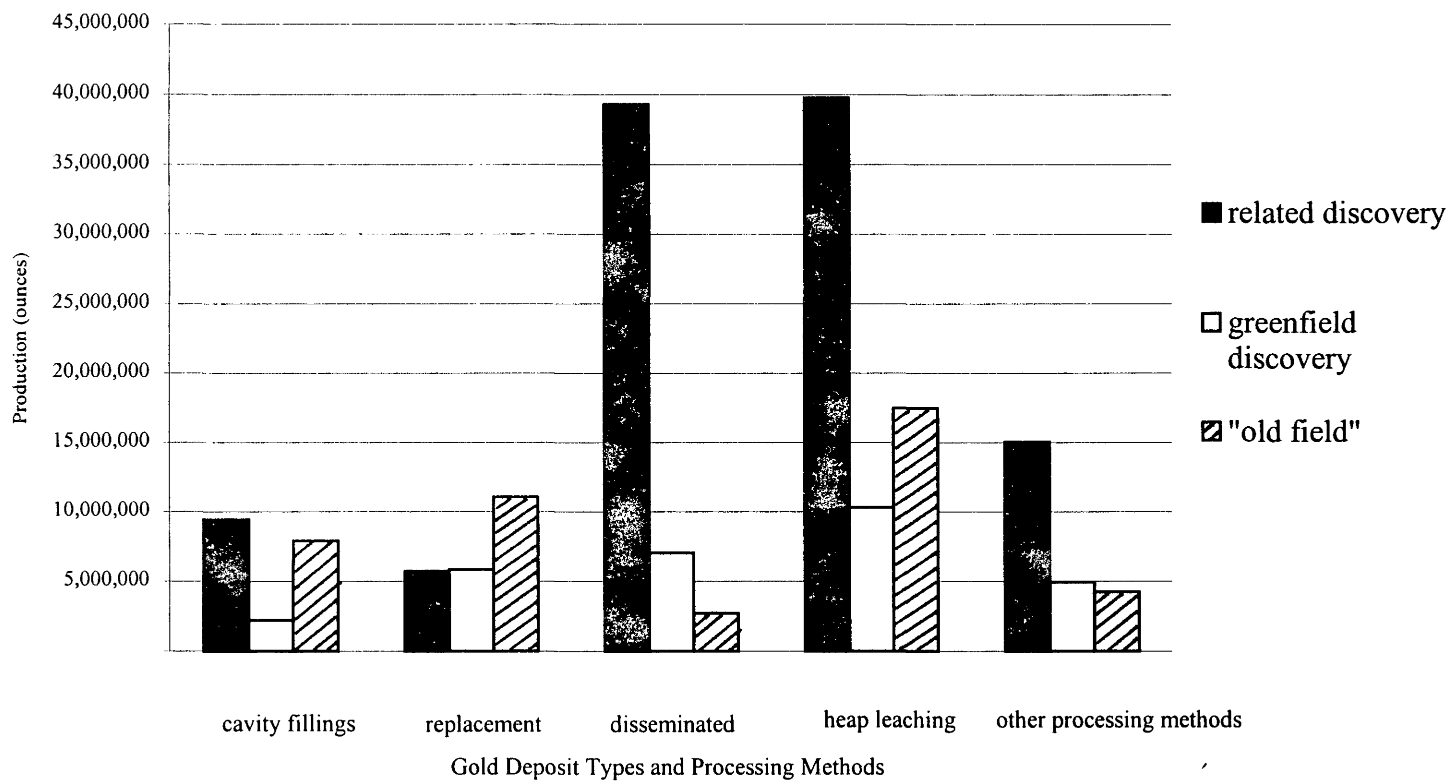

Figure 6.3 Production Classified by Development Types

(with different development types and processing methods)

Second, the main processing method used in "new field" category is clearly a heap leaching process, which is an efficient and economical method for most disseminated gold deposits. The amount of gold processed by heap leaching is almost equal to the amount of production from the disseminated gold deposit. The numerical data of "new field" is shown in Table D-1 in Appendix D.

On the other hand, the "old field" category, which comprises "previously mined" and "previously known deposits or mineralization" development types in the two-dimensional classification, has not shown the clear results of the "new field" category. However, there are two noticeable results related to both development types.

First, main sources of production in the "old field" category are cavity filling and replacement gold deposits. These deposits, which generally are vein type and silver-gold deposits, produced significant gold production for long periods until recently when disseminated gold deposits were recognized.

Second, heap leaching is still the favored method used in the "old field" category for both replacement and disseminated gold deposits. Note that some geologists classify disseminated deposits as one of many sub-types of replacement deposits because of similar geological appearances, but a disseminated deposit differs from a replacement deposit. Consider disseminated deposit as a subset of a replacement gold deposit, which might explain why heap leaching is applicable to replacement deposits. Most cavity filling deposits and some replacement deposits use other processing methods.

Figure 6.4 shows the distribution of gold deposits indicated in the proximity and lead time graph. By overlapping Figure 6.4 on to Figure 6.2, which shows production distribution, it can be seen that a significant production in "related discovery" comes from disseminated gold deposits. On the other hand, most production in the "old field" category comes from both replacement and cavity filling deposits. Another possible explanation is that before the opening of Carlin mine, the disseminated gold type was not be an exploration target, so "old field" sources came from other deposits. Several

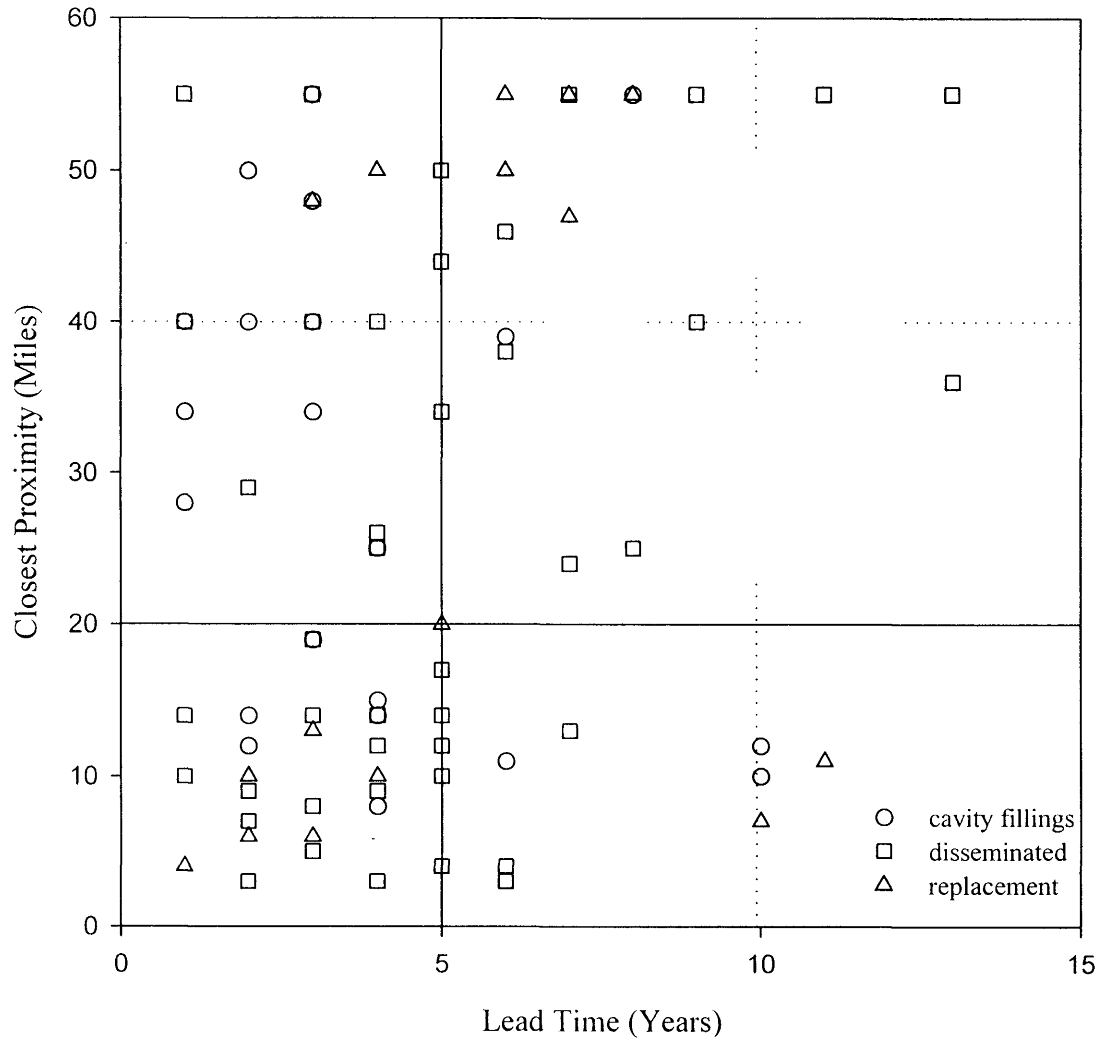

Figure 6.4 Lead Time and Proximity of New Mine Openings (includes deposit types shown by symbols)

possibilities exist to explain why mine openings from cavity filling deposits take longer to reach the production stage.

Basically, the cavity filling deposit requires underground mining in which an exploration tunnel can be changed easily to a production tunnel when the gold price is high enough to be profitable. However, once the mine is closed, due perhaps to exhausted ore reserves or low gold prices, it takes longer to make it a producing mine again. The reopened development of a previous underground mine is time-consuming because, when it is closed, the mine must be flooded to preserve underground structures. When a mine is closed because of depleting ore reserves, additional time my be required for exploring for new reserves and for work on feasibility studies before the mine can be reopened. In addition, adequate infrastructure may not be available in remote areas. Table D-1 in Appendix D also shows the numerical numbers related to the deposit types and processing methods used in the "old field."

6.2.0 Technology Improvements

Since the mid-1980s, new technologies of extraction and recovery, such as heap leaching and carbon adsorption, have been used to increase gold production. Since recognition of disseminated gold deposits (led by the Carlin deposit), most "new field" mines have used heap leaching to extract low-grade gold deposits, a more efficient and economical method than conventional processes, such as milling or gravity separations. The large production from disseminated deposits in "related discovery" and "greenfield" confirms the importance of heap leaching. Heap leaching is also a basic method for processing replacement deposits or even cavity filling deposits in "old field" mines. Figure 6.5 indicates the relationship of gold production, gold price, and major technological improvements in each development type.

Complex gold ores, however, such as refractory ores or some cavity filling deposits, always require more than one process. The combination of processing methods,

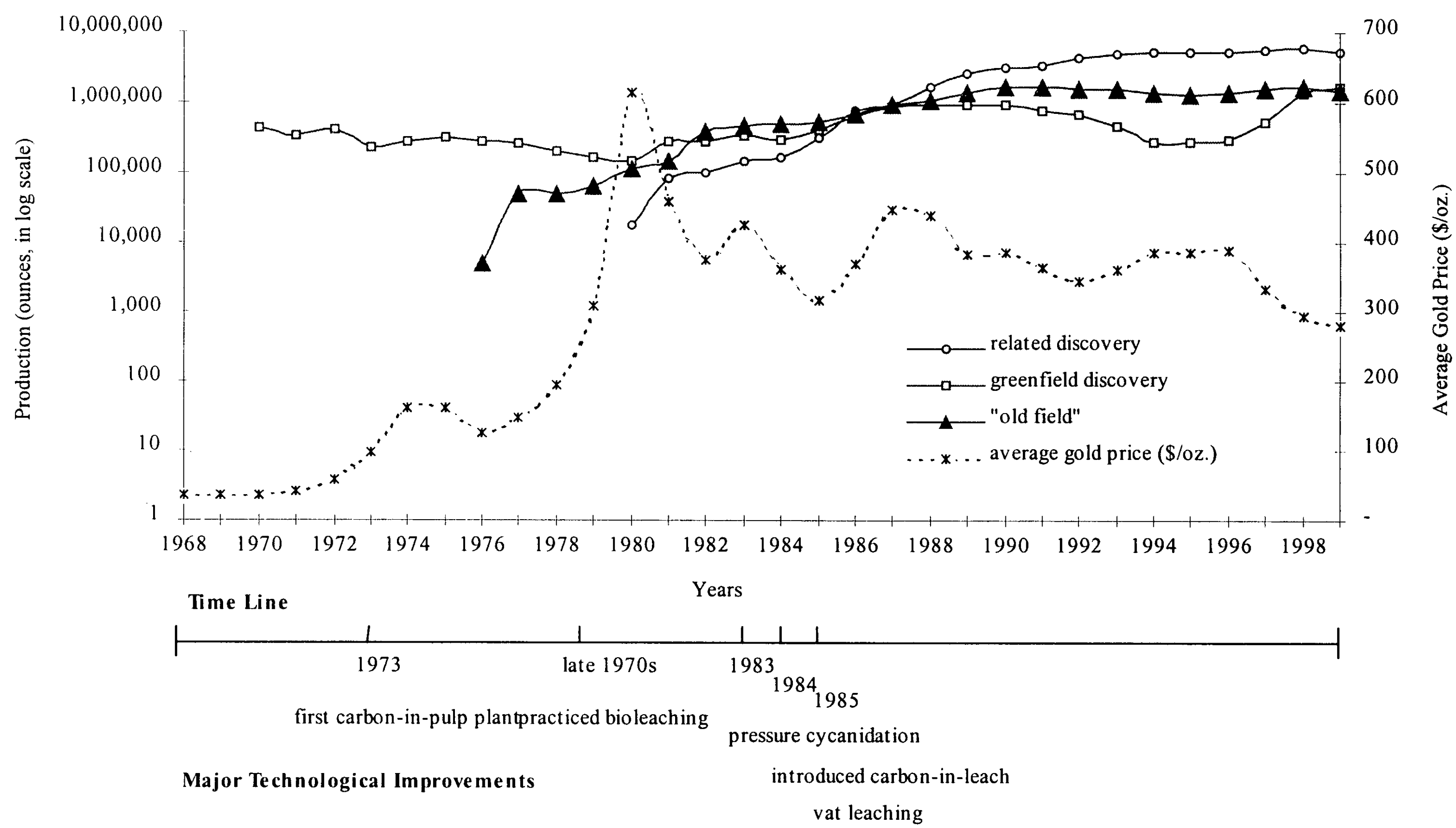

Figure 6.5 The Relationship Between Production and Gold Price in Development Types

say, a combination of heap leaching and milling, or flotation, allows a higher average production per mine than does heap leaching alone because cavity filling deposits geologically are of a higher grade than disseminated gold deposits.

The innovation of heap leaching significantly affected gold production of "new field" mines compared to "old field" mines. From Figure 6.3 (shown in section 6.2) "new field" production using heap leaching is approximately 50 million ounces, while "old field" production using the same technique is only 18 million ounces.

6.3 New Mine Openings and Production, 1970-2000

This section will examine, first, the relationship between new mine openings and development types; second, the lead time for the new mine openings; and, third, the role of new mine openings from 1970 to 2000 for gold production in Nevada.[4]

6.3.1 New Mines and Development Types

Figure 6.6 illustrates the number of mine openings classified by development types in 5-year periods from 1970 through 2000, and Table D-2 in Appendix D shows the numerical data, including the average 5-year gold prices and average lead-time in each development type. Mine openings that cannot be classified by development type are excluded.

The numbers from Figure 6.6 indicate that new mine openings increased substantially during the 1985-1989 period and have since declined. New mine openings from "related discovery" contributed almost 50 percent of the total new mine openings during the peak period. Beginning in 1980, the number of mine openings from "old fields" slowly increased along with "related discovery," but rapidly decreased after the

[4] Data on the number of new mine openings can be obtained for 2000, but production only through 1999.

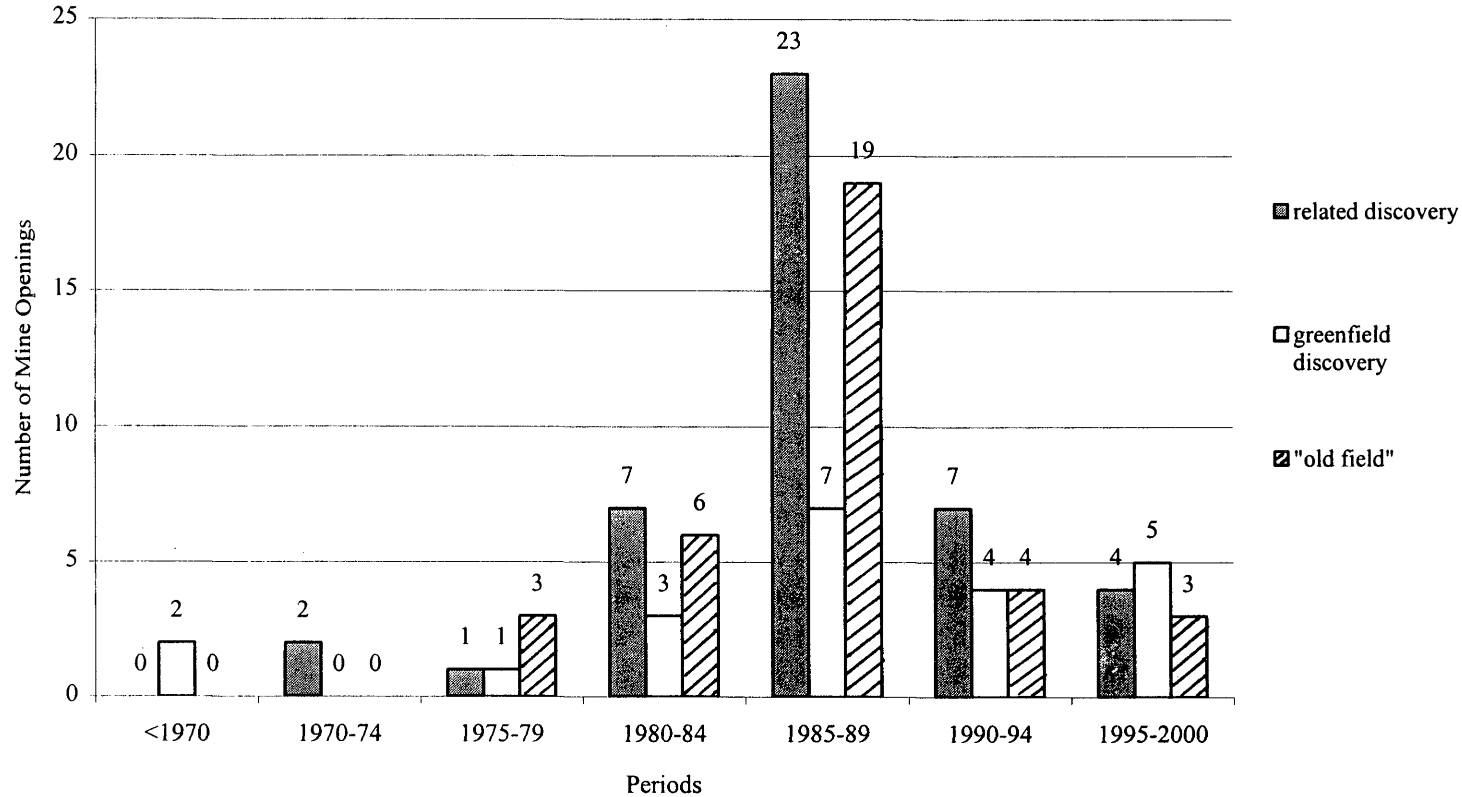

Figure 6.6 Number of Mine Openings Classified by Development Types in 5-Year Periods

peak period 1985-1989. Only a few mines opened in the 1990s. This decrease might indicate fewer exploration efforts to replace "old field" deposits during the 1990s, probably due to declining gold prices. It also indicates the strategy of mining companies that are interested in exploration mainly in areas surrounding the operating mines.

Mine openings from "old field" should not be overlooked, especially those from replacement and cavity filling, which indicates the amount of accumulative geological knowledge gained from the long periods of exploration. Gold production from these deposits flows into the gold markets whenever the prices are high enough to cover the marginal costs of production. Even though not all exploration efforts are successful, the knowledge gained from exploration can contribute to identifying "known mineralization or deposit" areas waiting for development.

6.3.2 Lead Time

The shortest average lead time for a mine to become a producing mine is about 3 years. "New field" mines have an average lead-time of 3 to 5 years. "Old field" mines have a lead time ranging from 8 to 10 years. The lead time base value of 5 years seems to be a reasonable value to distinguish between "new" and "old" fields.

The high gold price in 1980 ($160/oz) clearly prompted a surge in new mine openings, but the lag time to respond to the high prices appears to be at least 5 years. "New field" discoveries are mined faster than "old field" deposits, based on lead time and may be the reason why new mine openings mostly come from "new field" discoveries. The significant increase of gold prices in the late 1980s obviously contributed to the increase of new mines opened during the period 1980-1990. Also improvements and extended applications of heap leaching techniques in the mid-1980s stimulated more openings.

6.3.3 The Role of New Mines in Production

Figure 6.7 is similar to Figure 6.6, but shows the new mine production classified by development type in each period, instead of by the number of mine openings. Table D-3 in Appendix D contains the numerical data for each development type. Even though 50 new mines opened in the 1985-1989 period, their accumulated total production was only 5.8 million ounces, or an average production of 0.116 million ounces per mine. In the 1980-1984 period, 16 new mines produced a total of 2 million ounces, or an average production of 0.128 million ounces per mine. In addition, 15 new mines in the 1990-1994 period produced 2.6 million ounces, or an average production of 0.172 million ounces per mine. These figures indicate the small size of the reserves and the low average production of mines opened in the 1985-1989 period. In addition, most new mines in this period are "related discovery," new mines clustered heavily in the active mining areas, a finding that adds support the mining company strategy of exploration mentioned earlier.

The total production from both new mine openings and mines operated at the beginning of each 5-year period (existing mines) classified by development type is shown in Figure 6.8 and Table D-4 in Appendix D. Total gold production dramatically increased after 1985, from 14 million ounces during the 1985-1989 period to 38 million ounces during the 1995-1999 period. "Related discovery" is obviously the principle source of production in the last two periods, but did the production come from new mines that started production in that period? Obviously, it did not. As illustrated in Table 1.4, new mine production contributed a maximum of 59 percent and 40 percent of the total production only during the 1980-1984 and 1985-1989 periods, and less than 10 percent in the last two periods. If the new mines opened in the past 10 years, did this not mainly contribute to the significant production in the past 10 years? Where did the production come from, especially in "related discovery"?

Figures 6.9 and 6.10 (Table D-5 in Appendix D) classify the number of mines and production, respectively, from mines that operated only at the beginning of a period or

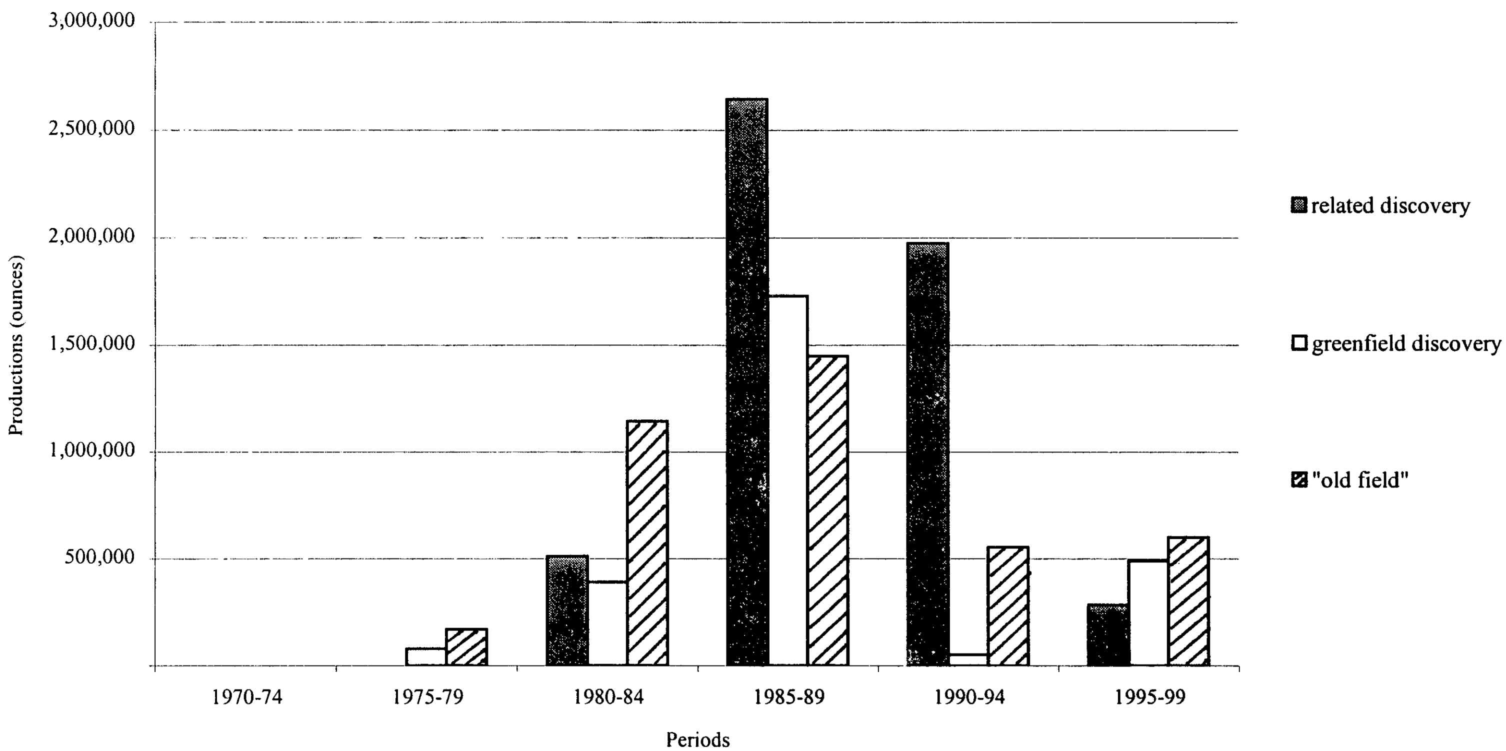

Figure 6.7 Total Production of New Mine Openings Classified by Development Types in 5-Year Period

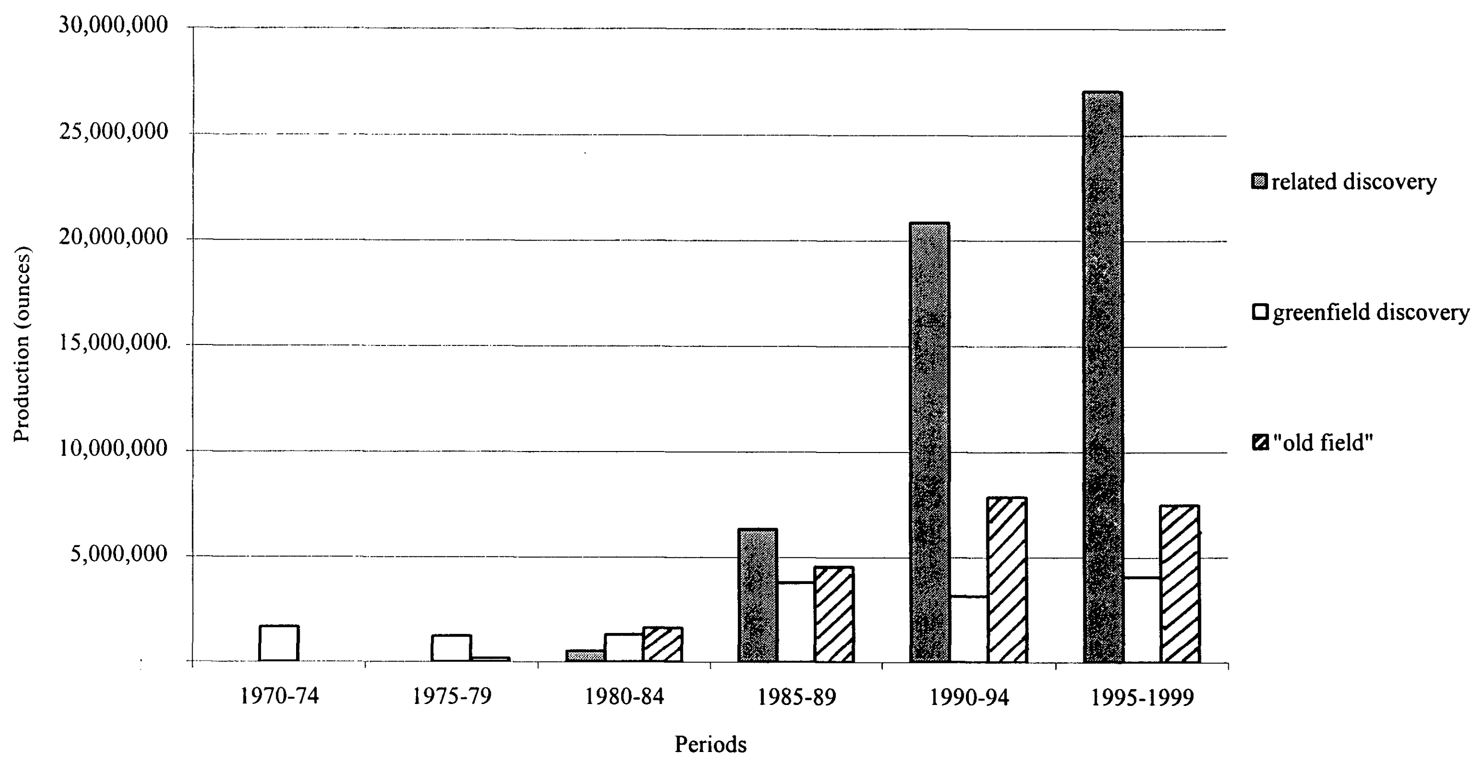

Figure 6.8 Total Period's Production from Both New Mine Openings and Existing Mines Classified by Development Types in 5-Year Period

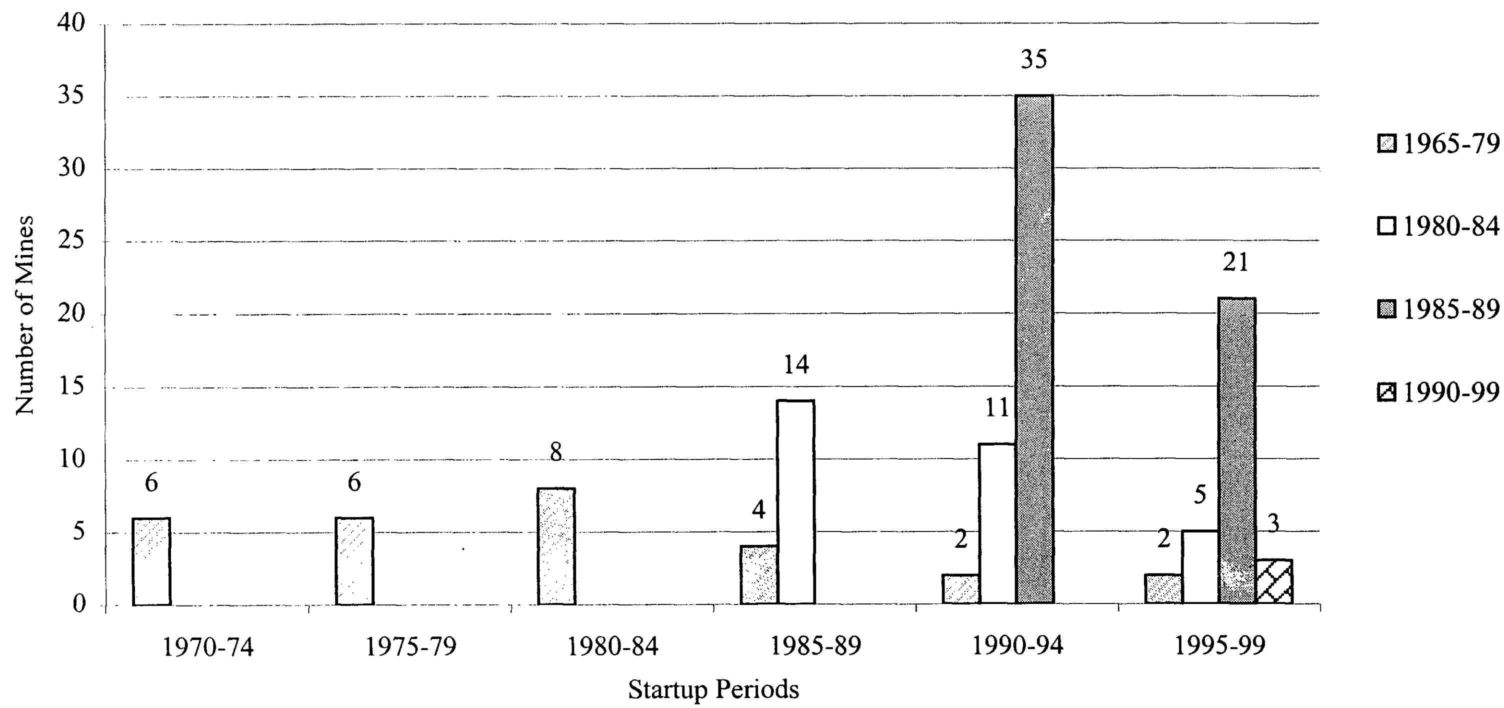

Figure 6.9 Number of Existing Mines Classified by Startup Periods

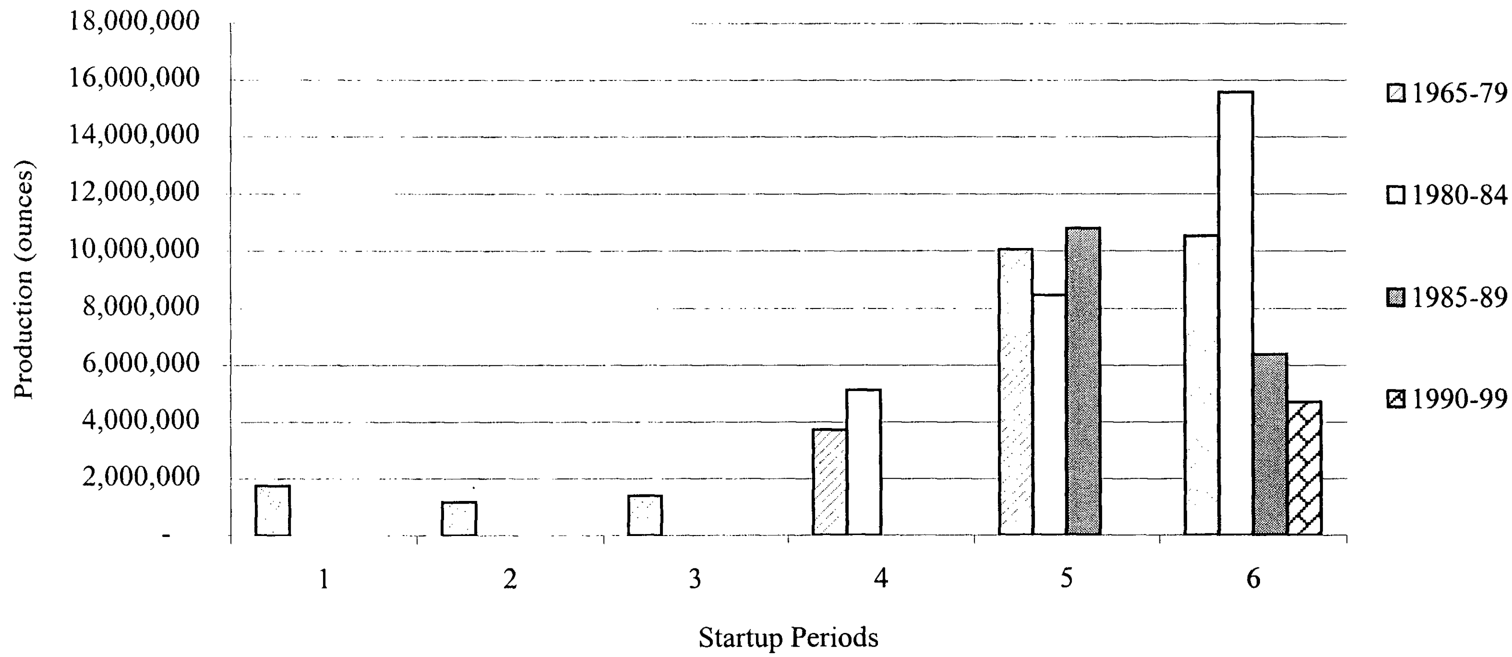

Figure 6.10 Production of Existing Mines Classified by Startup Periods

existing mines by start-up period. It does not include new mines opened in that period. These two figures show two results. First, production in the 1995-1999 period came mostly from mines that opened in the 1980-1984 period. To be more specific, only 5 mines from this period produced the accumulated production of almost 16 million ounces from the total period production of 38 million ounces. Second, mines that opened in the 1980-1984 period had higher average production per mine than mines opened in the 1985-1989 period during the last 10 years.

The important mines that opened in the 1980-1984 period and continued producing are Betze-Post, Battle Mountain (Fortitude), Bald Mountain (Alligator Ridge), Cortez (Horse Canyon), Jerritt Canyon, and Pinson mines. These mines are mostly "related discovery" which is why production in the last 10 years (see Figure 6.8) shows a large contribution from "related discovery." However, it is important to note that Figure 6.10 exaggerates the production from mines started during the 1965-1969 period, especially regarding the Carlin mine, which has been producing gold since 1965. Production from the Carlin Trend mines that opened after 1970 have been included in Carlin's production and shown in 1965-1969 period. Some production from Carlin mine should be distributed to other periods. For example, Maggie Creek opened during 1980-1984, and Gold Quarry, Rain, and Genesis opened during 1985-1989.

New mine production from disseminated gold deposits and other deposits in each period were classified by development type (Figures 6.11, 6.12, and Table D-6 in Appendix D). These figures can implicitly represent the changes of production sources at different locations, which can reflect what and where mining firms should explore.

During the 1995-1999 period, the availability of disseminated gold deposits has decreased in surrounding areas of operating mines because these deposits were heavily exploited and extracted during the 1985-1994 period. This is shown by the decline of disseminated gold production in new mine openings, which is "related discovery." It is possible, however, that disseminated gold deposits exist in remote areas, a possibility

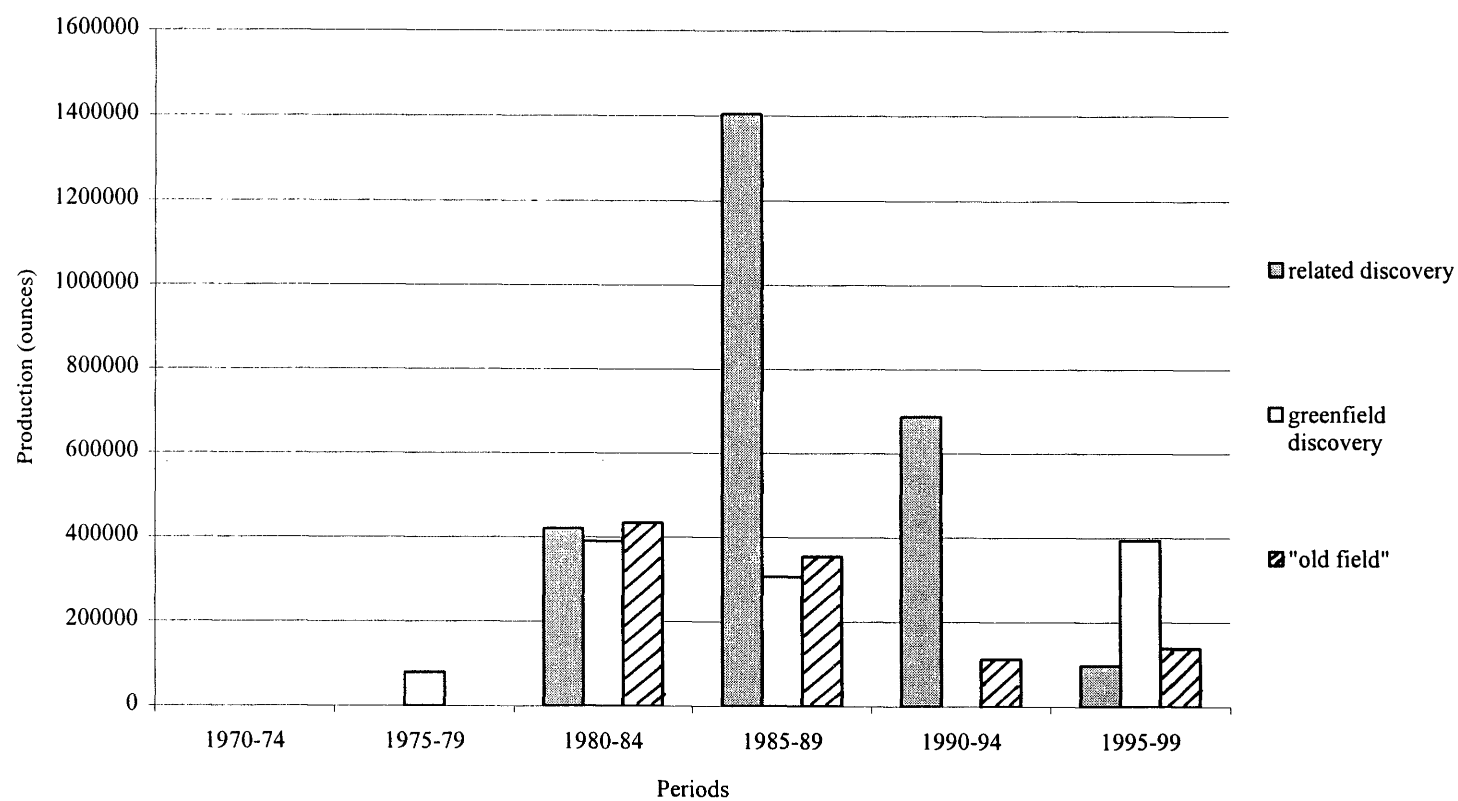

Figure 6.11 New Mine Production from Disseminated Deposits Classified by Development Types

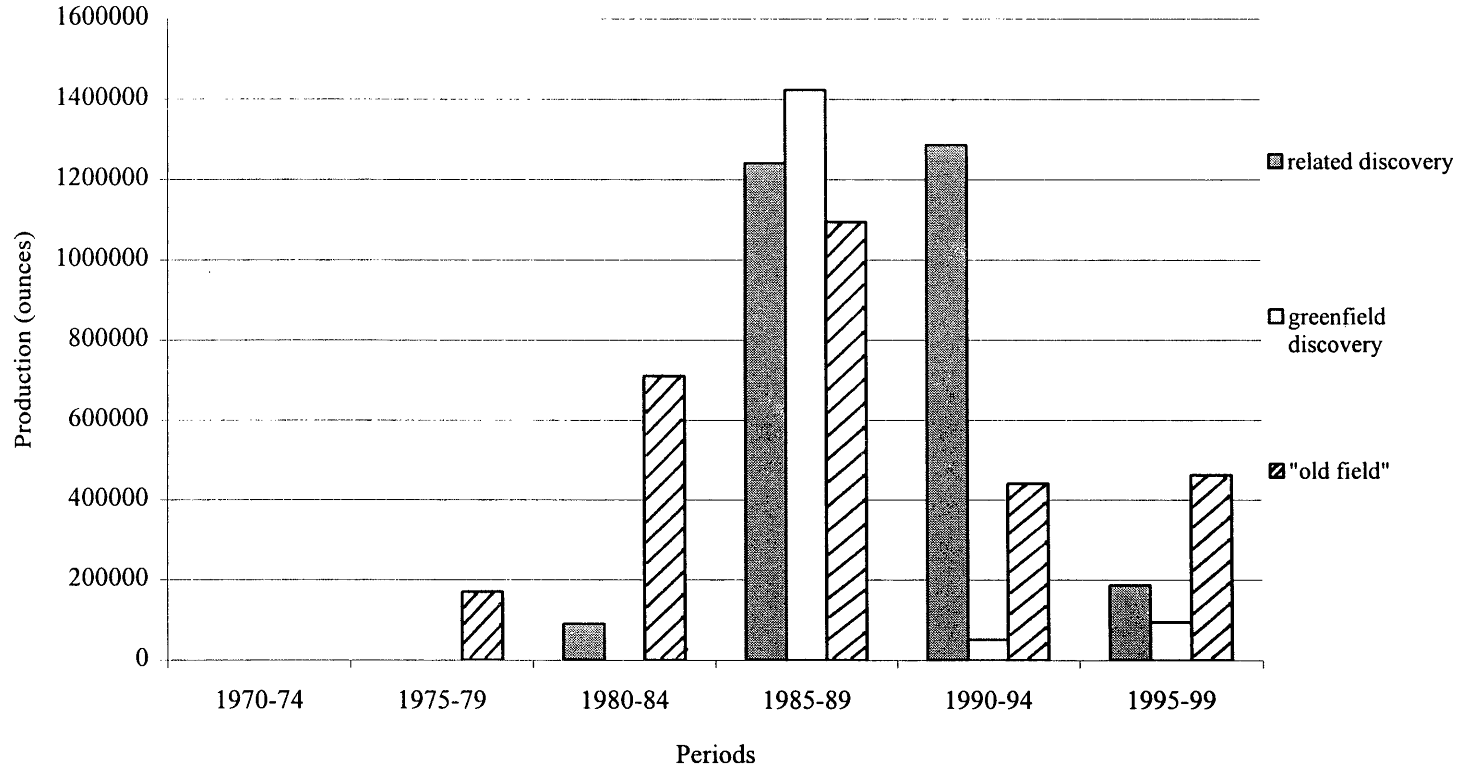

Figure 6.12 New Mine Production from Other Deposit Classified by Development Types

which is supported by the increase of disseminated gold production in new mine openings from "greenfield" development. (See Figure 6.11).

New mine production from other deposits, such as cavity filling, has shown a similarly declining direction (Figure 6.12). To open a new mine from a non-disseminated deposit requires "greenfield" exploration in both areas of known or unknown mineralization. Brownfield exploration for a non-disseminated deposit in closed or surrounding mining areas seems to be less practical, and previously known reserves are also depleting as well.

There are two possible reasons why other types of gold deposits, especially cavity-filling have been brought into production in "related discovery" and "old field," shown by the levels of production compared to production from disseminated deposits. First, the disseminated gold deposits near the surface have been depleted and are less available. Second, refractory ores located at sublevels can be mined and extracted at higher operating costs. Because of declining gold prices, cavity filling ores might be economical targets that ought to be developed because cavity filling ores have a higher ore grade, which means fewer tons processed, but a higher rate of production compared with refractory ores.

6.3.4 Technological Changes and New Gold Mine Openings

Discoveries of numerous low-grade gold deposits mainly in the western United States, along with deregulated gold prices, stimulated development of the low-cost cyanide heap-leaching technique. The first commercial use of heap leaching applied to gold processing was recorded in the late 1960s. The technology of heap leaching has been a major breakthrough for the gold industry, both for efficiency and economy.

Greatly improved technologies, as well as high gold prices, obviously contributed to the dramatic increase in mine openings from 1985-1989. Table 6.2 summarizes the chronological changes of extractive metallurgy of gold since the 1700s. Three major

Table 6.2 Chronological Changes in the Extractive Metallurgy of Gold

Events	Inventors/Discoverer	Year	Notes
First introduction a chemical technology for extraction of gold	Arab alchemist Jabir Ibn Hayyan	sixth century	6HCl + 2HNO3 +2Au --> 2AuCl3 + NO + 4H2O
Discovery "Berlin blue or Prussian blue," which is the origin of cyanide		1704	
Discovery chlorine	C.W. Scheele	1774	Chlorine can dissolve all metals, including gold.
Discovery potassium ferrocyanide	P.J. Macquer (French)	1718-84	A product of reaction of the Berlin blue with an alkali (KOH).
Created "Blue acid"	C.W. Scheele	1782	By heated Berlin blue with dilute sulfuric acid.
Called "Blue acid" as HCN	J.L.Gay-Lussac	1811	
Production of potassium cyanide	"unknown"	1834	By fusing potassium ferrocyanide with potash.
Elkington process	Elkington?	1840	Use potassium cyanide to prepare the eletrolyte for electroplating gold.
The important of oxygen in the dissolution of gold by potassium cyanide	L.Elsner	1846	
Use activated charcoal (feasibility study)	Lazowski	1848	
Use wood charcoal for recovery gold from chlorination	W.N. Davis	1880	
Precipitation of gold from cyanide solution by zinc cementation	"unknown"	1884	
Gold cyanidation process	J.S. MacArthur and Brothers R and W. Forrest	1887	
Use wood charcoal for recovery gold from cyanidation	W.D. Johnson	1894	First application of carbon adsorption.
Use of zinc dust in gold precipitation	C.W.Merrill	1904	
Corporated deoxygeneration and zinc dust	Crowe	1918	Called Merill-Crowe process.
Hydrogen theory	L.Janin	1888	
Hydrogen Peroxide theory	G.Bodlander	1896	
Cyanogen formation	S.B.Christy	1896	
Corrosive theory	B.Boonstra	1943	
Carbon-in-pulp (CIP)	T.G. Chapman	1939, 1950	First commercial CIP plant 1954-1960 at Golden Cycle Corporation's mill in Cripple Creek, Colorado.
Electrowinning	Zadra J.B.	early 1950s	
Electrolytic cell for the continuous electrowinning of gold from the strip solution.	Zadra and his coworkers USBM	early 1950s	And elution method " atmospheric process."
Atmospheric Zadra elution process	Zadra and his coworkers USBM	early 1950s	A major brakthrough for using activated carbon.
Application of high-pressure oxidation	American Cyanamid Co.	1957	Demonstration
Introduction of chemical oxidation (first development of low-cost cyanide heap leaching in massive scale)	USBM Nevada	late 1960s	Applied and tested to Calin-type gold ores (carbonaceous) in 1969, startup 1971 used chorine
First carbon-in-pulp plant	Homestake Mining and USBM	1973	Nettesheim' thesis (1988, p 54) say 1970.
High-pressure stripping process	Ross et al. and USBM	1970s	
MINTEK started work on CIP	MINTEK (South Africa)	1976	CIP plants have proliferated since late 1970s.
Alcohal stripping process	H.J. Heinen et al. and USBM	1979	An extension of Zadra process.
Bioleaching first practice application	USSR	late 1970s	Original study, Pasteur Institute (Paris) mid-1960s
Double oxidation	W.J. Guay	1980	First commercial plant, 1977
Anglo-American stripping process	R.J. Davidson	"unknown"	Requires a high capital cost.
Pressure cyanidation	H.B. Pietsch	1983	The method had been studied since 1950 but 1983 was the first commercial use (McLaughlin).
Carbon-in-leach with oxygen (CIL)	Elmore et al.	1984	Use oxygen instead of air
Vat leaching	"unknown"	-1985	

Sources: Compiled from Yannopoulos (1990) and W.J. Guay (1981, p.19-22) improvements occurred during the study period of 1970-1999. First, the development of low-cost cyanide heap leaching on a massive scale was tested on Carlin-type deposits in 1969, and adopted on a commercial scale in 1971. Second, the first commercial carbon-in-pulp plant was constructed in 1973. Third, the first commercial use of pressure cyanidation was introduced in 1983, and carbon-in-leach was improved by substituting oxygen for air in 1984. Basically, carbon absorption techniques, such as carbon-in-pulp processing, have proliferated since the late 1970s, but, as noted, they were in wide commercial use in the mid-1980s. Later technologies, after 1980, mostly aimed to find economical processing methods for refractory ores.

6.4 Discussion of the Results

The findings in this study differ from Trocki's because of differences in analysis, period of study, type of mineral (gold instead of iron and copper), location, and inclusion of technological innovations.

The methodology here also differs from Trocki's. Trocki used the number of mines, while this study uses total production to examine the impact of mine openings to mineral supply. However, the study here also indicates the number of mines in each development type (Table 6.1). If the analysis here is changed to consider the number of mine openings, as Trocki's did, the result remains the same and indicates that almost 70 percent of mine openings came from "new field" development types. Different study periods are ignored to obtain this conclusion.

Trocki studied iron and copper mine openings from the mid-1800s to the mid-1900s; the study period here is from 1970 through 1999. In addition, Trocki studied new mines opened in both the United States and foreign countries, while this study is limited to new mines opened only in Nevada. Trocki's period covers many world events, such as World Wars I and II, the Great Depression in the United States, and the industrial revolutions in both Britain and Germany. These events affected demand and supply in both iron and copper to some degree, which did not happen during the gold study period. The brief history of iron and copper shown in Table 6.3 indicates technological improvements and other events in chronological order.

Gold has a unique history in both price and processing technology. Significant increases in gold prices during the 1970-1980 period, and the proliferation of heap-leaching technology in the mid-1980s mainly contributed to the different final results of the two studies. Gold prices were deregulated in 1970. Afterward, the average gold price increased significantly: in 1970 from $35 per ounce to a peak of $612 per ounce in 1980. Although the average price has declined, it remains higher than in the early 1970s. The long period of high gold prices continued to stimulate investor interest and led to increases in the level of funding available to gold producers to invest in exploration, technology improvements, and productive capacity. High gold prices should have the same effect on both "new field" and "old field" developments. New mines are opened whenever marginal cost is less than market price. The numerous discoveries of low-grade, bulk gold deposits also triggered the search for new processing techniques. Innovations and improvements in heap leaching for low-grade gold deposits proliferated in the mid-1980s, and thus boosted the number of the new mine openings from both "new field" and "old field" sources.

Differences in study periods is an essential factor. An example of copper in the Trocki's work, exploration leading to new or follow-up discoveries (or "new field" in the study here) was the dominant development pattern for new mines opening between 1955 and 1975. During this time, the number of new discoveries of massive sulfides had a large influence on "new field" openings, accounting for 50 to 70 percent of the new mine openings compared to only 30 percent in the 1950-1954 period (Trocki, 1989, p. 222 and 251). Development of heap leaching and in-situ leaching applied to low grade ores, like massive sulfide, widely adapted to a commercial scale during 1960s to 1970s. Solvent extraction–electrowining (SX-EW) was introduced on a large scale in 1968, and oxygen "flash" smelting began in 1970 (Wilburn, 2001).

Table 6.3 Chronological Changes in Iron and Copper Technology and Events

Time	History of **Iron and Steel** Technology
before 1300s	Iron ore was burned with charcoal in a pit
1300s	Two furnaces for smelting iron were developed: Catalan and Stuckofen furnace.
1500	Blast furnace was developed in England.
mid-1800s	The main two processes used to make steel were cementation and crucible process.
1858	The first successful application of the Bessemer took place.
1860	A type of open hearth stove called Cower stove was introduced by Seimens.
1864	Open hearth stove was widely used.
1866	Seimens-Martin process was introduced.
1879	The electric arc furnace was invented but was not commercially applied until 1900s.
1880	Blast furnace was improved by using regenerative stoves.
1892	Mesabi range was discovered.
1894	Out put from open hearth process overtook Bessemer production.
1896	The first briquetting machine was developed.
1870-1990	Production increased because open hearth process could utilize some scrap and low grade ore as input.
1900s	Large blast furnaces were constructed. (from 450 tonnage of pig iron/day up to 1350 tonnage/day)
1934-1936	The most successful advance in pelletizing was achieved in the U.S.
1950	The commercial-scale production by using the basic oxygen furnace (BOF) began.
1955	BOF was constructed in the U.S.
1969	BOF production equalled open hearth furnace production and overtook afterward.

Time	History of **Copper** Technology
1698	The reverberatory furnace was first used at Swansea in South Wales.
early 1700s	Rolling mills began to gradually replace the manual hammering of copper.
1760	Industrial revolution in Britain
1770	Industrial revolution in Germany increased demand for iron, coal, and copper.
1820s	Copper production in Chile began to increase.
1840-60	Demand for copper for use in electricity generators rose sharply.
1850	Development of a multi-hearth roasting furnace to treat finely powdered ores due to depletion of high-grade lump ores
1865	The process for electrolytic refining was developed in England.
1869	The first electrolytic refining was installed near Swansea.
1873	The multi-hearth roasting furnace was greatly improved and replaced an old Welsh calcining furnace which has a slow roasting process.
1876	Bell invented the telephone.
late 1800s	Smeltors increased in size and decreased time to smelt a batch.
1880	The technology of Bessemer convertor was adapted to produce blister copper from matte copper.
1880s	The U.S. became a significant world copper producer.
1892	The first electrolytic refinning was built at Laurel Hill, New York.
1895	(1) Hand sorting was replaced by shaking table to aid in separating heavy particle during washing. (2) Integrating mining and processing mills at mine sites.
early 1900s	(1) Improved mining techniques by apply block caving method to copper mining; Bingham, Utah. (2) Forth flotation for concentration was successfully applied to the Broken Hill zinc mine in Australia.
1915	Forth flotation technique was used in Arizona for sulfide ore.
1920s-1930s	The roast-leach-electrowin technique was applied to the oxide ore in Zaire and Zimbia.
1930-32	Great Depression caused copper prices and production to plummet.
1960s-1970s	The development of heap leaching and in situ leaching of low grade ores.
1967	Copper prices increased sharply and subsequently fluctuated significantly until 1980s.
1968	SX-EX was introduced on a large scale.
1970	Oxygen "flash" smelting began production.

Sources: Compiled from Trocki (1989)

This period in copper history is similar to developments taking place simultaneously in the gold industry. A new type of copper deposit (massive sulfide) and technology improvements (heap leaching, SX-EW, and oxygen "flash" smelting) to extract that specific deposit are identical to disseminated gold deposits and heap leaching, with both metals, more than 50 percent of new mines opened from "new field."

Comparisons of gold and iron histories are less obvious. In the post-World War II period, "new field" generally accounted for roughly 30 percent of new iron mines, with the exception of 50 percent between the early 1900s and the late 1910s, and a 1955-1959 period (Trocki, 1989, p.254). No solid evidence to support the hypothesis of any new type of deposit affected "new field" mines, but technology did lead to the opening of "new field" mines by use of commercial scale basic oxygen furnaces (BOF) in 1950. The first furnace was constructed in the United States in 1955. After 1969, production has been mainly from the BOF technique.

Of great interest is the proportion of new mines opened from the "new field." Before technological improvements were applied to new deposits (the "technology-new deposit" model outlined above), both new iron and copper mines opened from "new field" is about the same, 30 percent. In other words, about 70 percent of new mines opened from "new field" after the introduction of new technology, remarkably similar to the finding in the gold study! This finding is worth exploring further because, if it is consistent among mineral commodities, it might be applied to the allocation of exploration budgets. For instance, mining firms might allocate 70 percent of their exploration budgets to "new field" explorations (probably greenfield or brownfield) during the period that the technology-new deposit model applies, if the model does not apply, then, 30 percent. Study or application should further investigate beyond Nevada.

Finally, the findings in this study of gold mine openings in Nevada probably apply to all U.S. gold mine openings because Nevada's gold production dominates total U.S. gold production. Mine openings in other states were roughly examined in the preliminary study. There are only a few mines that have significant gold production, such as McLaughlin and Mesquite mines in California, Homestake mine in South Dakota, and Bingham Canyon mine in Utah. Approximate total production in ounces of McLaughlin, Mesquite, Homestake and Bingham Canyon mines are 2.2 million, 1.1 million, 6.8 million, and 2.8 million, respectively. Even though the analysis categorizes these mines as "old field" development types, total production combined together (roughly 13 million ounces) during the study period is far less than the total production of "new field" development types in Nevada (70 million ounces). Thus, the results will likely remain the same.

6.5 Sensitivity Analysis

Production and the number of mine openings change when geographic proximity and lead times vary from the base values fixed at a 20 miles radius and a 5-year period, respectively. Table 6.4a shows the results of all development types at varied proximities.

The "new field" category drops significantly in both number of mines and production between "related discovery" and "greenfield discovery" when the value of proximity is reduced from 20 miles to 10 miles and from 50 miles to 40 miles. On the other hand, insignificant changes occur in both number of mines and production in "new field" when the value of proximity varies between 20 to 40 miles. This indicates less sensitivity compared to the decreasing proximity (20 miles to 10 miles).

The "old field" category shows no changes in numbers of mines and production in all values of proximity because of no effects from varied proximities.

In summary, changes in proximity value do not affect the result that the number of mines and production of "new field" far exceed those in "old field." In addition, changes do not affect the outcome that "related discovery" is a primary source of supply compared to "greenfield discovery," but do affect the number of mines and production switching between "related discovery" and "greenfield discovery." The 20-mile based value is a pre-designed value based on geological information. The number seems to be a

Table 6.4a Sensitivity Analysis Results from Varied Proximity

		Lead Time (Timing)	
		less than or equal to 5 years (new field)	more than 5 years (old field)
Geographic Proximity to Mining	10 miles or closer	34 mines 46.90 million oz.	35 mines 21.71 million oz.
	more than 10 miles	37 mines 23.13 million oz.	
	20 miles or closer	46 mines 54.79 million oz.	35 mines 21.71 million oz.
	more than 20 miles	25 mines 15.24 million oz.	
	30 miles or closer	55 mines 55.68 million oz.	35 mines 21.71 million oz.
	more than 30 miles	16 mines 14.36 million oz.	
	40 miles or closer	59 mines 58.05 million oz.	35 mines 21.71 million oz.
	more than 40 miles	12 mines 11.99 million oz.	
	50 miles or closer	67 mines 67.00 million oz.	35 mines 21.71 million oz.
	more than 50 miles	4 mines 3.03 million oz.	
		71 mines	35 mines

reasonable proximity because it is in an acceptable range between 20 and 40 miles, and also gives the same outcomes.

Changing the lead time from 5 years to 7 or 10 years has an insignificant effect on both the number of mines and production in "new field", especially in "related discovery." On the other hand, "greenfield discovery" noticeable changes from increasing the lead time, switching from "old field." Approximately 10-15 mines and 10 million ounces of production are moved from "old field" to "new field" because of the increasing lead time. Table 6.4b shows the results of all development types at varied lead times.

The results will be completely changed, however, if the lead time is decreased from 5 to 3 years. "Old field" production and number of mines will be higher than with "new field," confirming Trocki's results. More than 41 million ounces of production and 18 mines will switch from the "new field" to the "old field" category. These changes also indicate that first, many high-producing and "related discovery" mines have lead times between 3-5 years, and second, a primary shift of production occurs in "related discovery," not in "greenfield discovery."

It is difficult to say what the reasonable lead time is between 3 and 5 years. However, the study here offers some help. First, lead time is difficult to calculate unless the definition of discovery is strictly defined and used. Without a strict definition, the lead time can be plus or minus one year from the record. Second, average lead time from all mines in this study is approximately 5 years, and more than 3 years[5] in the "new field" category only (categorized by using the 5-year base value). Third, Ivosevic's study (1984, p.131), indicates that the lead time required to develop a deposit increases at a 40 percent annual rate with advancing year[6] of start-up probably because of increasing regulatory and environmental regulations, and capital investments. A trend of increasing lead times is possible.

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[5] The actual figures are 4.84 and 3.11 years, respectively.
[6] Ivosevic collected the data of some gold mines from 1965 to the end of 1980s.

Table 6.4b Sensitivity Analysis Results from Varied Lead Times

		Lead Time (Timing)							
		less than or equal to 3 years (new field)	more than 3 years (old field)	less than or equal to 5 years (new field)	more than 5 years (old field)	less than or equal to 7 years (new field)	more than 7 years (old field)	less than or equal to 10 years (new field)	more than 10 years (old field)
Geographic Proximity to Mining	20 miles or closer	28 mines 13.10 million oz.		46 mines 54.79 million oz.		48 mines 54.91 million oz.		51 mines 55.48 million oz.	
			61 mines 65.65 million oz.		35 mines 21.71 million oz.		24 mines 12.47 million oz.		5 mines 0.76 million oz.
	more than 20 miles	17 mines 12.99 million oz.		25 mines 15.24 million oz.		34 mines 24.36 million oz.		50 mines 35.51 million oz.	
		45 mines	61 mines	71 mines	35 mines	82 mines	24 mines	101 mines	5 mines

Considering the above, a mine opening with a 3-year lead time is possible, but it could, as well, be 2 or 4 years. Mine openings with lead times between 3 and 5 years exhibit high production. Using the 5-year lead time to classify mine openings provides more confidence than using the 3-year lead time because a new and high producing mine is more likely to take more than 3 years to develop. Using the 5-year lead time seems to be a reasonable base value.

6.6 Mine Location

Figure 6.13 provides a rough picture of the locations of gold mine openings in Nevada over the past 30 years. Using a grid system, mine locations are plotted, including 4 cities for references. The dotted horizontal line roughly indicates the same level of route 80. Mining activities cluster around the northern part of the state on three mineral trends: Carlin, Cortez, and Getchell.

Mine production from these trends are significant as shown by the size of the circles in Figure 6.14, especially the Carlin trend. The moderate size of the circle located at the middle of the figure is Round Mountain area (includes Manhattan), which also has a long history of production. The small circle located approximately 100 miles northwest of Las Vegas is a previous underground mining areas, which includes the Bullfrog mine.

A few new mines opened on the three mineral trends during the last decade, (Figure 6.15). The new mines are located in the area between the trends or at the ends of trends, indicating that the explorations aimed to expand mining activities along the known mineral trends. However, several new mines opened during the 1990s in Eureka and White Pine counties (block 10-30N, 50-70E in Figure 6.15). From the geologic map,[7] these areas are located on the White Pine range and close to Mount Hamilton.

[7] Map 91: Bulk-Mineable Precious-Metal Deposits and Prospects in Nevada, Harold (1986), Nevada Bureau of Mines and Geology.

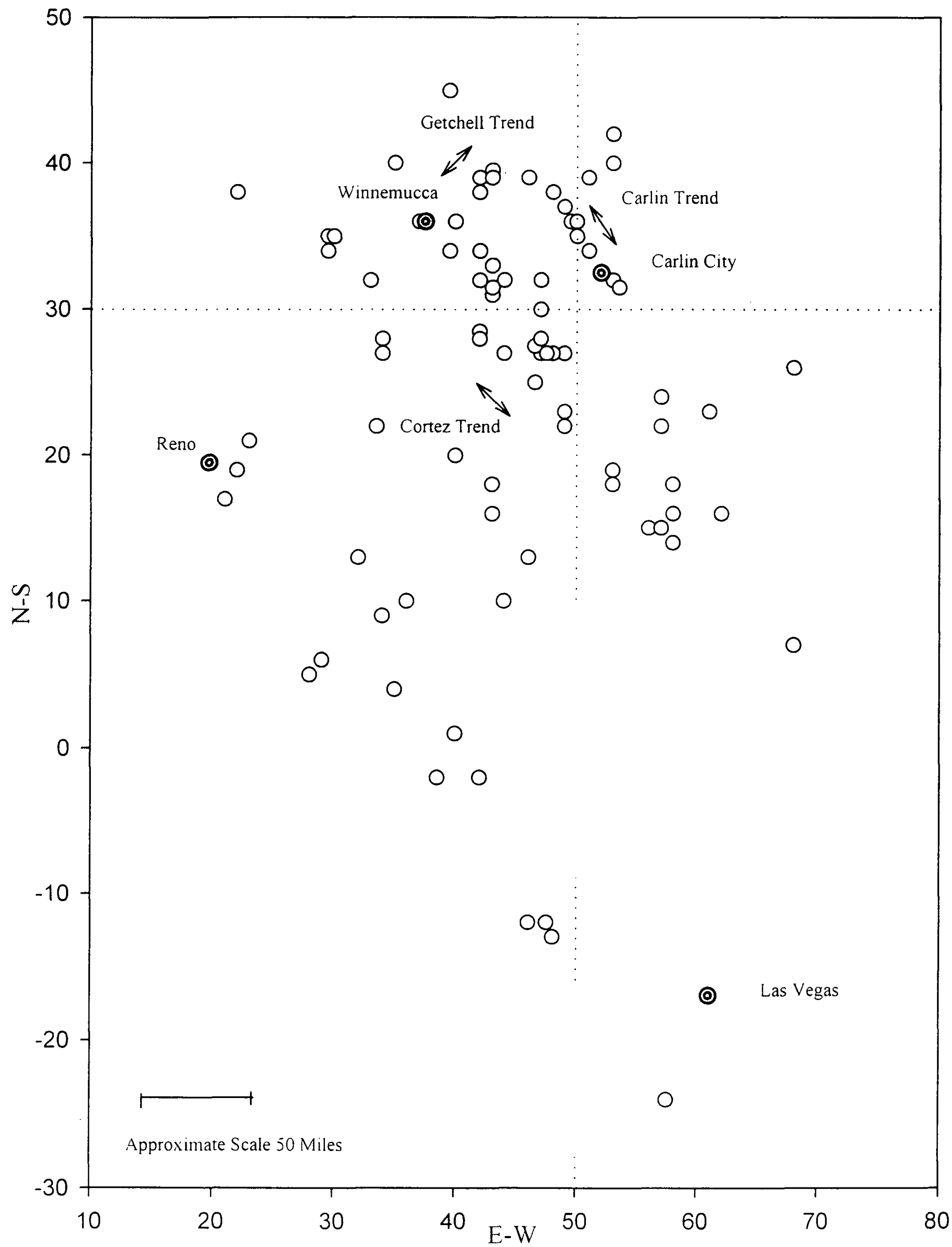

Figure 6.13 Mine Locations in Nevada

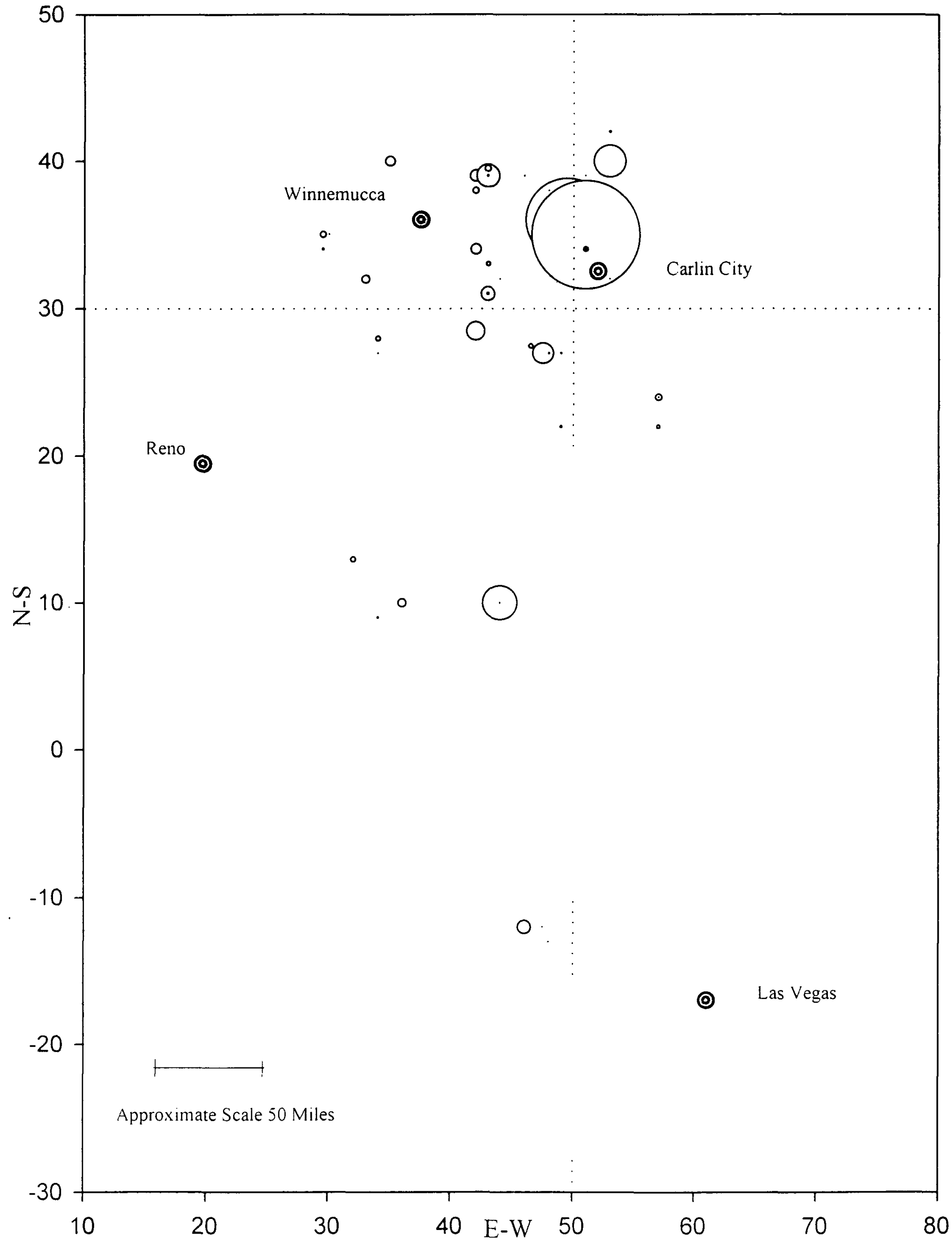

Figure 6.14 Mine Locations in Nevada (Includes production shown by size of the circle)

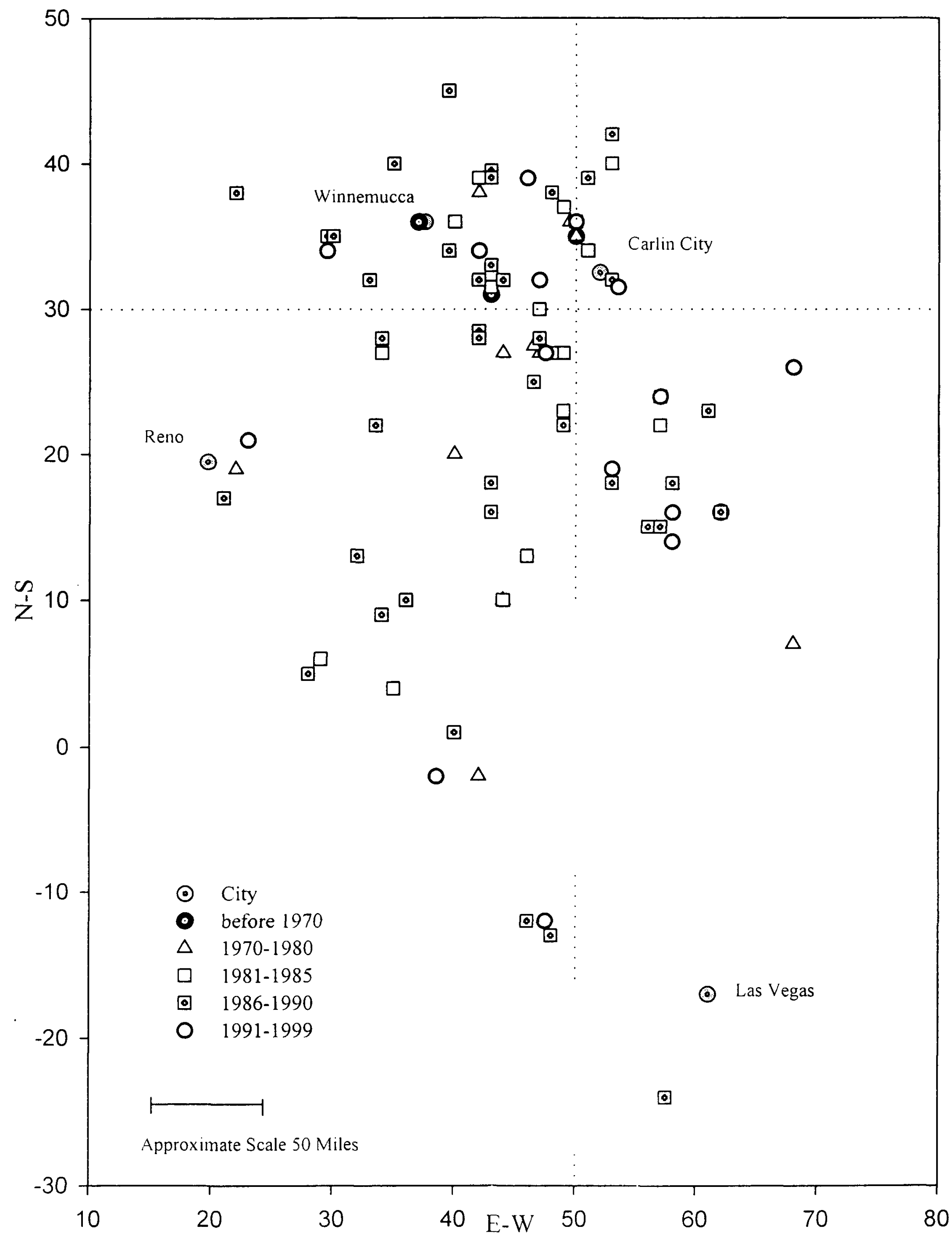

Figure 6.15 Mine Locations in Nevada Classified by Startup Years

They are also close to previous well-known copper deposits (Ruth areas). Gold-silver deposits were previously mined as well.

New mines that opened between 1981 and 1999 indicate that central Nevada, more specificly Lander, Eureka, and White Pine counties, may be the mineral potential areas for future exploration.

CHAPTER 7
SUMMARY AND CONCLUSIONS

In this chapter, section 7.1 summarizes overall findings. Section 7.2 summarizes why the results in this study are different from Trocki's findings, and section 7.3 presents study conclusions, followed by suggested applications and further research.

7.1 Summary

This study of mine openings in Nevada indicates that 76 percent of total past production of all new mines opened from 1970 through 1999 comes from the prompt development after discovery or "new field" category with less than a 5-year lead time. Of that 76 percent, the "related discovery" development type contributes nearly 60 percent, and the rest, 16 percent, from "greenfield discovery."

The disseminated gold deposits are the main sources of gold production for both "greenfield" and "related discovery" development types, especially in "related discovery." Disseminated gold production in "related discovery" alone contributed almost 40 million ounces (more than 70% of total production) in this particular development type.

The main processing method used in the "new field" category is heap leaching, an efficient and economical method for most disseminated gold deposits. The amount of gold processed by heap leaching is almost equal to the amount of production from disseminated gold deposits.

Unlike the "new field" category, the "old field" category does not show clear results about the processing-related gold type. However, there are two noticeable results. First, main sources of production in the "old field" category are undoubtedly vein-type deposits, such as cavity filling and replacement gold deposits, because the vein-type deposit was a primary source of gold supply before recognition of the disseminated gold deposit. Second, heap leaching can be applied to the "old field" deposits, especially for replacement deposits.

Complex gold ores, such as refractory ores or some cavity filling deposits, requires more than one processing technique. The combination of processing methods, which can be the combination of heap leaching and milling, or flotation, provide a higher average production per mine than heap leaching alone because cavity filling deposits geologically have a higher grade ore than disseminated gold deposits. The refractory ores are another possible source of future gold supply.

New mine openings from the "related discovery" category increased by 50 percent during the 1985-1989 period and have declined ever since. There are two reasons for the rise and fall. First, mining companies explore mainly in areas surrounding operating mines or brownfield exploration because disseminated gold deposits are widely recognized in such specific areas as the Carlin trend. Second, declining gold prices during the 1990s probably affected new mine openings.

Even though fifty new mines opened in the 1985-1989 period alone, their accumulated total production during that period was only 5.8 million ounces. An average production per mine is 0.116 million ounces, which is the lowest average production per mine compared to the average production of new mines opened in other periods. This indicates that new mines cluster heavily in established mining areas.

The proportion of production from new mines opened during the periods of 1980-1984 and 1985-1989 contributes a maximum of 59 percent and 40 percent of the total period production compared to less than 10 percent in the last two periods (1990-1994 and 1995-1999). Production from 1995 through 1999 came mostly from mines that opened during the 1980 to1984 period. To be more specific, only 5 mines that first started production during 1980-1984 produced almost 16 million ounces from the total 1995-1999 production of 38 million ounces. They are Betze-Post, Battle Mountain

(Fortitude), Bald Mountain (Alligator Ridge), Cortez (Horse Canyon), Jerritt Canyon, and Pinson mines. In addition, these mines are classified as "related discovery," so this also indicates the success of reserve replacement over time from brownfield exploration.

"New field" and "old field" mines have an average lead-time, ranging from 3 to 5 and from 8 to 10 years, respectively. Lag time to respond to the high gold prices is at least 5 years.

The trend of increasing production from "greenfield discovery" and from non-disseminated gold types occurred during the 1995-1999 period. Two possible reasons for why that happened are (1) the disseminated gold deposits from "related discovery" became less available, forcing to have more "greenfield" exploration. Furthermore, the study also indicates that disseminated deposits may be found by greenfield exploration, as observed from the increasingly disseminated production from "greenfield discovery" development. And (2) because gold reserves are always quickly depleted and gold prices are relatively low, the non-disseminated gold deposits are brought into production due to a secondarily available source of supply, one with a higher ore grade that gives more output per unit of operating costs and which stabilizes revenue.

The results from sensitivity analysis show insignificant changes in both number of mines and production in "new field," when the value of proximity varies between 20 to 40 miles. On the other hand, changes of proximity from based value 20 miles to 10 miles or beyond 50 miles are more sensitive to the number of mines and production. Changing the lead time from 5 years to 7 or 10 years has no significant effect on the number of mines and on the production in either "old" or "new" field, especially in "related discovery." On the other hand, the results are changed radically if the lead time is decreased from 5 to 3 years. More research is suggested here to determine whether a 3 or 5 year base value is the proper one to use. Outside factors, such as increasing environmental concerns or declining ore grades might suggest selection of a longer lead time (5 years) as used in this study.

7.2 Summary of the Discussion of the Results

Even though the methodology used in this study and Trocki's study is the same, certain factors in this study differ from Trocki's-analysis method, period of study, type of mineral study, and inclusion of technological innovations-cause the differences between Trocki's final results and the final results obtained from this study.

The Trocki study used number of mines, while this study uses total production to examine the impact of mine openings to mineral supply. In addition, a more objective classification system (the two-dimensional classification), is used here which adds two factors: lead time and proximity, increase more conditional factors, and widely differentiate both results.

Trocki studied iron and copper mine openings during the period from the mid-1800s to the mid-1900s, a much longer period than this study, 1970-1999. In addition, Trocki studied new mines opened in both the United States and in non-centrally-planned-economy countries, while this study considers only new mines in Nevada.

Difference in study periods is a critical factor to the results. The dominant development types are changing with time. The result of copper mine openings during the 1955-1975 period is similar to the result from this study that approximately 50-70 percent of the number of new mines opened came from "new field." During this specific period, new technologies were applied to a new specific mineral type, which this study calls "technology–new deposit" model. An example of copper, technologies of heap leaching, SX-EW, and oxygen "flash" smelting are applied to massive sulfide deposits. An example of gold history, heap-leaching technique were widely applied to the disseminated gold deposits during the 1970-1990 period. Some periods of iron history reflect similar events with similar results, but are less obvious than in the copper history. Technological improvements applied to a specific mineral deposit indicate a pattern of a continuing increase in the number of new mines from "new field."

7.3 Conclusions, Implications of the Study and Suggestions for Further Research

The role of exploration has either immediate or later impact on mineral supply. The role also changes with time because not all discovered deposits are promptly developed, depending upon economical, technological and regulatory factors. However, exploration activities cannot be definitely ignored because, even though the exploration fails to uncover new, high-grade deposits, the understanding of geological structures and models can increase over time, and also increase the chance of successful discovery later on. In addition, technological improvements or mineral prices can lower operating costs and increase marginal profits, and make previously uneconomic deposits profitable.

The need for replacement reserves forces the exploration manager or project manager to explore for new deposits or to evaluate previously uneconomic deposits. The expectation of high-grade deposits or new types of mineral deposits that can be found in new accessible territories influences greenfield exploration decisions. The decision also depends on available exploration techniques, mining and processing technology for new types of mineral deposits, and new ore deposit models. If exploration cannot take advantage of available applications, managers might consider other options to increase mineral supply, such as previously uneconomic projects or brownfield exploration. This study indicates that sources of mineral supply change with time and are related to both economic and technological changes.

Managers may learn insights from the history of new mine openings to answer questions of where and what type of mineral deposits to explore. For example, under specific times and circumstances–periods of technological innovations effectively applied to new deposits-"new field" development may be more favorable than "old field" development. Some of the results of this study may help gold companies scope potential areas of exploration and geological targets in Nevada, either greenfield or brownfield.

In addition, exploration budgets can be efficiently allocated by looking at what development type was the primary source of production based on relative and comparative circumstances with the past. The exploration expenditure should be allocated more on that specific development type. The proportion of new mines opened from a specific development type during specific circumstances can be another interesting further study that might be applied to budget allocation.

Further, policy makers should not provide incentives only for exploration but also for research on mining, processing, and exploration improvements in order to lower operating costs and sustain a domestic mining industry.

There is room for future research related to this study. Mines opened during the 1980-1984 period have shown continuity of significant production until now. These mines are worth further study of their deposits and locations to develop ways on how these mines can continue to replace depleting reserves over time. Cash costs of production and refractory ores processed can shed more light on the effects of gold prices and technology improvements on the openings of new mines. Finally, the possible future research should also study whether the implications of this study can be applied beyond Nevada.

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APPENDIX A
IDENTIFIED PRODUCTION OF NEW MINES IN NEVADA

Table A Identified Production of New Mines in Nevada During 1970-99 Classified into Six 5-Year Periods

Period 1970-74			
Mines in Operation at the Beggining of 5-Year Period	Production (Ounces)	New Mines	Production (Ounces)
Big Mike-later cls.	1,916	Blue Star s-74	see Carlin
Carlin s-65	904,806	Gold Acres s-74	see Cortez
Copper Canyon s-67	71,562	Ruth Pit s-70	85,273
Cortez Gold s-69	693,061		
Tripp Pit-cls.71	38,090		
Veteran Pit-cls.71	38,090		
Total Production	1,747,525		85,273

Period 1975-79			
Mines in Operation at the Beggining of 5-Year Period	Production (Ounces)	New Mines	Production (Ounces)
Blue Star s-74	see Carlin	Atlanta s-75	79,120
Carlin s-65	921,500	Bootstrap s-75	see Carlin
Copper Canyon	129,356	Gooseberry s-77	15,000
Cortez Gold-exh.	101,600	Round Mountain s-77	120,000
Gold Acres-exh.	see Cortez	Windfall s-76	35,000
Ruth Pit-cls.	28,145		
Summation of Production	1,180,601		249,120

Period 1980-84			
Mines in Operation at the Beggining of 5-Year Period	Production (Ounces)	New Mines	Production (Ounces)
Atlanta-idle	50,000	Aurora s-83	4,438
Blue star	see Carlin	Alligator Ridge s-81	265,500
Bootstrap	see Carlin	Battle Mnt. (Fortitude) s-84	100,000
Carlin	639,263	Betze-Post s-80	188,000
Copper Canyon-cls.	229,000	Borealis s-81	225,686
Gooseberry-cls.	31,727	Buckhorn s-84	4,000
Round Mountain	399,875	Candelaria s-82	9,000
Windfall-cls.84	50,000	Dee Gold s-84	6,388
		Fire Creek s-83 & cls.	767
		Horse Canyon s-83	81,500
		Jerritt Canyon (Enfield) s-82	701,055
		Maggie Creek s-81	see Carlin
		Manhatton s-83	46,125
		Northumberland s-81	88,112
		Pinson s-80	300,096
		Relief Canyon s-84	24,500
		Thomas W s-80 & cls.	600
Summation of Production	1,399,865		2,045,767

(continued)

Table A (continued)

Period 1985-89			
Mines in Operation at the Begginning of 5-Year Period	Production (Ounces)	New Mines	Production (Ounces)
Aurora s-83	25,583	Austin s-86 & cls.	191,000
Alligator Ridge s-81	289,386	Aurora Part. s-87	41,141
Battle Mt. s-84	1,243,507	Bald Mt. s-86	186,630
Betze-Post s-80	458,826	Big Springs s-87	119,376
Blue Star	54,000	Buckskin s-89	111,292
Bootstrap	see Carlin	Buffalo s-87	28,900
Borealis s-81	310,835	Bullfrog s-89	50,011
Buckhorn s-84	141,434	Chimney s-88	422,556
Candelaria s-82	47,800	Coeur s-86	159,436
Carlin (NGC)	2,626,143	Easy Junior s-89	5,000
Cortez-Horse-reo.	251,191	Florida s-86	193,998
Dee Gold s-84	239,935	Flowery s-88	836
Jerritt Canyon (Enfield) s-82	1,448,268	Fondaway s-89	1,065
Manhatton s-83	122,299	Genesis s-87	58,000
Northumberland- idle	54,667	Getchell s-85	111,195
Pinson s-80	356,324	Gold Bar s-87	156,562
Relief Canyon s-84	135,810	Golden Butte s-89	12,187
Round Mountain	1,049,664	Gold Field s-89	1,987
		Gold Quarry s-85	871,871
		Green Spring s-88	42,000
		Hycroft-Lewis s-87	180,300
		Kinston s-87	62,036
		Little Bald Mt.s-85	23,685
		Lllipah s-86 & cls.	14,116
		Marigold s-89	1,539
		McCoy&Cove s-86	459,575
		Mother Lode s-89	1,000
		North Star s-88	see NGC
		Paradise s-87	645,100
		Post s-88	see NGC
		Preble s-85	81,328
		Project Glister s-89	8,450
		Rain s-87	see NGC
		Robertson s-89 & cls.	3,700
		Robinson s-86	235,008
		Santa Fe s-89	73,484
		Sleeper s-86	776,658
		Star Pointer s-87	50,000
		Sterling s-86	27,030
		Surprise s-87	2,000
		Toiyabe s-87	64,600
		Tonkin s-85	27,782
		Tuscarora s-87	33,024
		Weepah s-86	58,000
		Western s-86	144,660
		White Pine s-88	25,493
		Windfall s-88	8,580
		Wind Mt.s-89	30,900
		Wood Gulch s-89	20,710
Summation of Production	8,855,672		5,823,801

(continued)

Table A (continued)

Period 1990-94			
Mines in Operation at the Beggining of 5-Year Period	Production (Ounces)	New Mines	Production (Ounces)
Aurora s-83	55,964	Adelaide s-90	4,917
Aurora Part. s-87	175,778	Casino s-90	48,953
Alligator Ridge s-81	50,785	Denton s-90	430,000
Bald Mt. s-86	407,365	Elder Creek s-90	20,102
Big Springs s-87	294,865	Gooseberry s-90 & cls.	7,055
Betze-Post s-80	5,296,676	Hollister s-90 & cls.	112,214
Battle Mt. s-84	779,059	Keystone s-90	1,000
Borealis s-81, cls.-90	18,435	Lone Tree s-91	549,927
Buckhorn s-84, cls.-94	56,855	Oliver Hill s-91	573
Buckskin s-89	428,316	Pipeline s-94	n/a
Buffalo s-87, cls.-90	15,770	Rabbit Creek s-90	296,500
Bullfrog s-89	1,398,767	Rain-Emi. s-93	see NGC
Candelaria s-82	31,553	Reona s-94	12,000
Carlin (NGC) s-65	8,060,400	Silver Peak s-90	31,000
Chimney s-88	696,034	South Pipe s-94	see CJV
Coeur s-86	299,507	Twin Creeks s-93	984,497
CJV (Cortez JV) s-83	289,456	Wright Window s-92 & cls.	3,500
Dee Gold s-84	178,370	Yeekee s-91	77,025
Easy Junior s-89	6,500		
Florida s-86	454,830		
Flowery s-88	15,533		
Fondaway s-89, idle	12,000		
Getchell s-85	1,032,200		
Gold Bar s-87, cls.-94	278,171		
Golden Butte s-89	32,568		
Gold Field s-89	11,350		
Green Spring s-88, cls.-91	21,000		
Hycroft-Lewis s-87	468,354		
Jerritt Canyon (Enfield) s-82	1,703,861		
Little Bald Mt.s-85	1,491		
Marigold s-89	392,415		
McCoy&Cove s-86	1,595,853		
Mother Lode s-89, cls.-93	30,000		
Paradise s-87, cls.-94	826,003		
Pinson&Preble s-85	257,229		
Relief Canyon s-84, cls.-90	4,100		
Robinson s-86	145,687		
Round Mountain s-77	1,991,014		
Santa Fe s-89	268,734		
Sleeper s-86	772,792		
Sterling s-86	66,265		
Toiyabe s-87	20,480		
Tonkin s-85, idle	2,068		
Tuscarora s-87, idle	1,163		
Western s-86	85,583		
White Pine s-88, cls.-90	6,767	some incls. in Twin Creeks	
Wind Mt.s-89, cls.-94	257,569		
Wood Gulch s-89, cls.-90	14,926		
Summation of Production	29,310,461		2,579,263

(continued)

Table A (continued)

Period 1995-99			
Mines in Operation at the Beggining of 5-Year Period	Production (Ounces)	New Mines	Production (Ounces)
Aurora s-83, cls.-98	40,788	Daisy s-96	94,113
Aurora Part. s-87, cls.-96	22,576	Deep Star s-95	2,800
Bald Mt. s-86	570,945	Griffon s-98	62,661
Betze-Post s-80	10,678,881	Ken Synder s-98	186,702
Battle Mt. s-85	271,063	Kinsley s-95	138,151
Bullfrog s-89	873,832	Mineral Ridge s-96	63,471
Candelaria s-82, cls.-98	38,971	Mt. Hamilton s-95	124,000
Coeur s-86	382,881	Mule Canyon s-96	62,135
CJV s-83	3,147,220	North Star	started new pit
Dee Gold s-85	198,555	Olinghouse s-98	31,567
Denton s-90	477,196	Rosebud s-97	338,303
Easy Junior s-89, cls.-98	14,982	Ruby Hill s-96	268,541
Florida s-86	749,324		
Flowery s-88	7,496		
Getchell s-85	804,321		
Gold Field s-89	15,036		
Hycroft-Lewis s-87	460,648		
Jerritt Canyon (Enfield) s-82	1,659,392		
Big Springs s-87, cls.	1,780		
Lone Tree s-91	1,263,163		
Marigold s-89	362,372		
McCoy&Cove s-86	1,060,775		
NGC s-65	8,241,976		
Pinson&Preble s-85	185,764		
Robinson s-86	223,070		
Round Mountain s-77	2,288,154		
Santa Fe s-89, cls.	16,670		
Sleeper s-86, cls.-96	120,262		
Sterling s-86, cls.	39,578		
Twin Creeks s-93	2,964,257		
Western s-86, cls.	3,000		
Summation of Production	37,184,928		1,372,444

Sources:

1. American Mines Handbook 2000 for 1997-98 data
2. Disseminated/Replacement Gold Deposits, 1981, Minobras Mining Services
3. Economic Gold Deposit, 1984, Minobras Mining Services
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APPENDIX B

DETAILED INFORMATION OF ALL NEW MINES IN NEVADA, 1968-1999

Table B-1 Gold Production in Nevada 1968-1999

Gold Production (in ounces) 1968-1975

Mine Names	County	1968	1969	1970	1971	1972	1973	1974	1975
Adelaide Crown	Humboldt								
Atlanta	Lincoln							st.	9,357
Aurora-Prospectus	Mineral								
Aurora Partnership	Mineral								
Austin Gold Ventures	Lander								
Bald Mountain	White Pine								
Alligator Ridge	White Pine								
Casino/Winrock	White Pine								
Yankee	White Pine								
Barick Goldstrike Property	Eureka								
Meikle	Eureka								
Betze-Post/Goldstrike	Eureka								
Battle Mountain Complex	Lander								
Copper Canyon	Lander			18,189	16,202	20,000	4,298	12,873	20,777
Fortitude Extension deposit	Lander								
Reona Project	Lander								
Surprise	Lander								
Big Mike	Perishing			1,916					
Borealis	Mineral								
Buckhorn	Eureka			exp.					
Buckskin-National	Humboldt								
Buffalo Valley	Lander								
Bullfrog-Barrick	Nye								
Candelaria	Mineral								
Coeur Rochester	Pershing								
Cortez Joint Venture (CJV)	Lander								
Cortez Gold	Lander		st.	209,000	120,251	183,810	75,700	104,300	73,900
Cortez Gold/Horse Canyon	Lander								
Cresent Pit	Lander								
Gold Acres/Little Gold Acres	Lander						st.	inc.	
Horse Canyon	Eureka								
Pipeline	Lander								
South Pipeline Project	Lander								
Daisy Gold	Nye								
Dee Gold	Elko								
Denton-Rawhide	Mineral								

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1968-1975

Mine Names	County	1968	1969	1970	1971	1972	1973	1974	1975
Easy Junior Project (Nighthawk Ridge)	White Pine								
Elder Creek	Lander								
Fire Creek	Lander								
Florida Canyon	Pershing								
Flowery (Golden Eagle)	Storey								
Fondaway Canyon	Churchill								
Getchell/Turquise Ridge	Humboldt			exp.			exp.		
Gold Bar	Eureka								
Golden Butte	White Pine								
Goldfield Operation	Esmeralda								
Gooseberry	Storey								
Green Springs	White Pine								
Griffon Gold	White Pine								
Hollister (Ivanhoe)	Elko								
Hycroft (Crofoot/Lewis)	Humboldt								
Lewis	Humboldt								
Jerritt Canyon/Savel Canyon	Elko								
Big Springs (Sammy Creek)	Elko								
Ken Snyder	Elko								
Keystone (Goodsprings)	Clark								
Kingston (Sumich)	Lander								
Kinsley Mountain	Elko								
Little Bald Mountain	White Pine								
Llipah	White Pine								
Lone Tree Complex	Humboldt								
Marigold	Humboldt								
Mary-Drinkwater	Esmeralda								
Mineral Ridge/Mary-Drinkwater	Esmeralda								
Silver Peak	Esmeralda								
McCoy/Cove	Lander								
Mother Lode/Sunday Night/Anomaly	Nye								
Mt. Hamilton	White Pine								
Mule Canyon	Lander								

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1968-1975

Mine Names	County	1968	1969	1970	1971	1972	1973	1974	1975
Newmont Gold Corporation	Eureka								
Blue Star	Eureka						dev.	st., inc.	inc.
Bootstrap	Eureka						dev.	st.-	inc.
Carlin	Eureka			201,000	199,000	194,306	150,000	160,500	213,000
Deep Star	Elko								
Genesis	Eureka								
Gold Quarry	Eureka								
Maggie Creek	Eureka								
North Star	Eureka								
Post/Deep Post	Eureka								
Rain	Elko								
Rain Emigrant Springs	Elko								
West Leeville Project	Eureka								
Northumberland	Nye								
Olinghouse	Washoe								
Oliver Hills	Storey								
Paradise Peak	Nye								
Pinson/Preble/Mag Pit	Humboldt								
Preble	Humboldt								
Project Glister	Eureka								
Relief Canyon	Pershing								
Robertson	Lander								
Robinson	White Pine								
Rosebud	Pershing								
Round Mountain (Smoky Valley)	Nye								st.
Manhattan	Nye								
Ruby Hill	Eureka								
Ruth Pit	White Pine			st.	13,106	21,606	30,306	20,255	14,861
Santa Fe	Mineral								
Sleeper	Humboldt								
Star Pointer	White Pine								
Sterling	Nye								

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1968-1975

Mine Names	County	1968	1969	1970	1971	1972	1973	1974	1975
Thomas W	Lander								
Toiyabe	Lander								
Tonkin Springs	Eureka								
Trinity	Pershing								
Tripp Pit	White Pine			24,984	13,106	po.			
Tuscarora (Dexter)	Elko								
Twin Creeks	Humboldt								
Chimney Creek	Humboldt								
Rabbit Creek	Humboldt								
Veteran Pit	White Pine			24,984	13,106	po.			
Weepah	Esmeralda								
Western Hog Ranch	Washoe								
White Pine	White Pine								
Windfall	Eureka						int.		st.
Wind Mountain	Washoe								
Wood Gulch	Elko								
Wright Window	Elko								
Summation of Identified Production (oz.)		-	-	480,073	374,771	419,722	260,304	297,928	331,895
Total State Production (oz.)		317,382	456,294	480,144	374,878	419,748	260,437	298,754	332,814
Average Gold Price ($/oz.) [2]				36	41	59	98	160	161

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1976-1984

Mine Names	1976	1977	1978	1979	1980	1981	1982	1983	1984
Adelaide Crown									
Atlanta	19,979	20,000	19,784	10,000	10,000	10,000	10,000	10,000	10,000
Aurora-Prospectus							st.-	538	3,900
Aurora Partnership								10,000	
Austin Gold Ventures									
Bald Mountain									
Alligator Ridge					st.	70,000	61,000	70,000	64,500
Casino/Winrock									
Yankee									
Barick Goldstrike Property				st.	18,000	40,000	40,000	40,000	50,000
Meikle									
Betze-Post/Goldstrike									
Battle Mountain Complex									100,000
Copper Canyon	25,579	25,000	33,000	25,000	25,000	60,000	60,000	84,000	
Fortitude Extension deposit									
Reona Project									
Surprise									
Big Mike									
Borealis					st.	42,500	61,000	63,500	58,686
Buckhorn								st.-	4,000
Buckskin-National									
Buffalo Valley									
Bullfrog-Barrick									
Candelaria							9,000		
Coeur Rochester									
Cortez Joint Venture (CJV)									
Cortez Gold	27,700	mo.							
Cortez Gold/Horse Canyon									
Cresent Pit									
Gold Acres/Little Gold Acres		mo.							
Horse Canyon							st.	35,500	46,000
Pipeline									
South Pipeline Project									
Daisy Gold									
Dee Gold								st.-	6,388
Denton-Rawhide									

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1976-1984

Mine Names	1976	1977	1978	1979	1980	1981	1982	1983	1984
Easy Junior Project (Nighthawk Ridge)									
Elder Creek									
Fire Creek							st.	300	467
Florida Canyon									
Flowery (Golden Eagle)		exp.							
Fondaway Canyon									
Getchell/Turquise Ridge									st.-
Gold Bar									
Golden Butte									
Goldfield Operation					exp.			dis.	
Gooseberry	st.	p.	p.	15,000	9,761		res.	6,966	15,000
Green Springs									
Griffon Gold									
Hollister (Ivanhoe)									
Hycroft (Crofoot/Lewis)									
Lewis									dis.
Jerritt Canyon/Savel Canyon		exp.	dis.	dev.		st.	195,714	262,000	243,341
Big Springs (Sammy Creek)									
Ken Snyder									
Keystone (Goodsprings)									
Kingston (Sumich)									
Kinsley Mountain									
Little Bald Mountain									st.-
Lllipah									
Lone Tree Complex									
Marigold									
Mary-Drinkwater									
Mineral Ridge/Mary-Drinkwater									
Silver Peak									
McCoy/Cove									
Mother Lode/Sunday Night/Anomaly									
Mt. Hamilton									
Mule Canyon									

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1976-1984

Mine Names	1976	1977	1978	1979	1980	1981	1982	1983	1984
Newmont Gold Corporation									
Blue Star	inc.	id.		int.					
Bootstrap	inc.	inc.	inc.	inc.	inc.	inc.	inc.	id.	
Carlin	208,000	215,100	152,400	133,000	110,000	130,000	145,000	164,859	89,404
Deep Star									
Genesis									
Gold Quarry					dis.				st.
Maggie Creek					dis.	p.	p		res.
North Star									
Post/Deep Post									
Rain									
Rain Emigrant Springs									
West Leeville Project									
Northumberland					st.	12,112	18,000	23,000	35,000
Olinghouse									
Oliver Hills									
Paradise Peak									
Pinson/Preble/Mag Pit				st.	56,000	56,000	66,038	56,458	65,600
Preble									st.
Project Glister									
Relief Canyon								st.-	24,500
Robertson									
Robinson									
Rosebud									
Round Mountain (Smoky Valley)		40,000	40,000	40,000	40,000	73,000	72,561	93,300	121,014
Manhattan				p.			res.	26,500	19,625
Ruby Hill									
Ruth Pit	2,307	10,977	p.	sd.					
Santa Fe					dis.				
Sleeper									
Star Pointer									
Sterling								st.	

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1976-1984

Mine Names	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**
Thomas W					600				
Toiyabe									
Tonkin Springs									st.-
Trinity									
Tripp Pit									
Tuscarora (Dexter)									
Twin Creeks									
Chimney Creek									
Rabbit Creek									
Veteran Pit									
Weepah									st.
Western Hog Ranch									
White Pine									
Windfall	5,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Wind Mountain									
Wood Gulch									
Wright Window									
Summation of Identified Production (oz.)	288,565	321,077	255,184	233,000	279,361	503,612	748,313	956,921	967,425
Total State Production (oz.)	287,962	324,003	260,895	250,097	278,495	524,802	757,099	960,657	1,020,546
Average Gold Price ($/oz.)	125	148	194	308	613	460	376	424	361

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1985-1993

Mine Names	1985	1986	1987	1988	1989	1990	1991	1992	1993
Adelaide Crown					st.	3,068	1,849	id.	
Atlanta	id.								
Aurora-Prospectus	900		res.	12,000	12,683	12,973	11,607	12,284	8,600
Aurora Partnership		st.-	3,014	10,302	27,825	31,000	36,390	39,132	39,285
Austin Gold Ventures	st.-	49,700	49,700	41,600	50,000	mo.			
Bald Mountain	st.-	34,899	48,000	48,619	55,112	60,128	55,043	81,582	90,612
Alligator Ridge	70,000	74,200	46,100	45,029	54,057	18,000	17,366	10,454	4,965
Casino/Winrock					st.-	6,039	19,979	19,745	3,190
Yankee						15,000		10,800	11,272
Barick Goldstrike Property	52,000	40,000	40,144	119,418	207,264	352,880	546,146	1,108,218	1,439,929
Meikle								dis.	
Betze-Post/Goldstrike					exp.	inc.	inc.	inc.	inc.
Battle Mountain Complex	222,000	259,000	255,000	253,000	254,507	261,338	233,522	178,569	57,630
Copper Canyon									
Fortitude Extension deposit								dis.	
Reona Project									st.
Surprise		st.-	2,000	inc.	inc.	inc.			
Big Mike									
Borealis	51,368	38,752	45,459	86,256	89,000	18,435	mo.		exp.
Buckhorn	16,842	37,000	36,700	22,000	28,892	19,300	21,700	7,706	4,057
Buckskin-National					111,292	102,000	131,960	127,849	66,507
Buffalo Valley		st.	7,763	9,238	11,899	15,770	sd.		
Bullfrog-Barrick				st.	50,011	220,192	198,863	323,825	354,887
Candelaria		12,000	11,000	11,000	13,800	11,796	2,870	2,431	1,810
Coeur Rochester	st.-	4,195	26,821	52,388	76,032	59,082	60,565	56,562	66,412
Cortez Joint Venture (CJV)			50,781	42,322	39,993	53,945	53,500	45,553	66,850
Cortez Gold									
Cortez Gold/Horse Canyon			inc.	inc.		inc.	inc.	inc.	inc.
Cresent Pit									
Gold Acres/Little Gold Acres		st.	inc.	inc.	inc.	inc.	inc.		
Horse Canyon	56,000	62,095	inc.	inc.					inc.
Pipeline							dis.		
South Pipeline Project								dis.	
Daisy Gold									dis.
Dee Gold	47,647	51,000	47,000	49,788	44,500	48,095	42,046	38,150	25,860
Denton-Rawhide		dev.			st.	39,000	76,000	92,000	105,000

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1985-1993

Mine Names	1985	1986	1987	1988	1989	1990	1991	1992	1993
Easy Junior Project (Nighthawk Ridge)					5,000	6,500			
Elder Creek					st.	17,400	2,702		
Fire Creek									
Florida Canyon	st.-	3,400	47,800	61,314	81,484	83,200	80,586	89,954	109,190
Flowery (Golden Eagle)			st.	836		6,000		2,253	2,200
Fondaway Canyon				st.-	1,065	12,000			id.
Getchell/Turquise Ridge	6,500	10,100	16,200	19,500	58,895	172,029	200,958	218,748	210,465
Gold Bar		st.	37,000	53,562	66,000	81,263	80,727	55,080	55,080
Golden Butte				st.-	12,187	22,362	8,970	1,073	163
Goldfield Operation					1,987				11,350
Gooseberry	5,000		res.	4,057	8,011	5,012	2,043	sd.	
Green Springs			st.-	12,000	30,000	16,000	5,000	mo.	
Griffon Gold									dis.
Hollister (Ivanhoe)					st.	6,000	59,978	34,836	10,320
Hycroft (Crofoot/Lewis)		st.	13,700	75,800	82,000	92,600	94,340	100,030	86,516
Lewis			8,800	inc.					
Jerritt Canyon/Savel Canyon	255,341	270,000	315,900	310,100	296,927	323,000	374,354	318,020	361,820
Big Springs (Sammy Creek)		st.-	5,000	54,000	60,376	73,224	69,539	71,035	52,752
Ken Snyder									
Keystone (Goodsprings)					st.-	1,000			idle
Kingston (Sumich)		st.-	8,441	39,247	14,348	6,070			
Kinsley Mountain				dis.					
Little Bald Mountain	3,330	4,330	5,425	5,100	5,500		990	501	
Llipah		st.	4,000	9,016	1,100	mo.			
Lone Tree Complex						st.-	36,424	128,000	158,592
Marigold				st.-	1,539	60,784	65,469	90,771	90,496
Mary-Drinkwater									
Mineral Ridge/Mary-Drinkwater									
Silver Peak					st.	6,000	25,000		
McCoy/Cove	st.-	91,000	50,000	104,009	214,566	255,044	284,327	301,512	395,610
Mother Lode/Sunday Night/Anomaly				st.-	1,000	30,000		id.	mo.
Mt. Hamilton				st.					id.
Mule Canyon								exp.	

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1985-1993

Mine Names	1985	1986	1987	1988	1989	1990	1991	1992	1993
Newmont Gold Corporation				895,530	1,467,800	1,676,300	1,575,700	1,588,000	1,666,400
Blue Star			54,000	inc.					
Bootstrap				st., inc.			id.		
Carlin	112,713	120,000	30,100	inc.	id.		inc.		
Deep Star									
Genesis	dis.	st.	58,000	inc.					
Gold Quarry	77,571	354,000	440,300	inc.	inc.	inc.	inc.	inc.	inc.
Maggie Creek		int.							
North Star				inc.					
Post/Deep Post				inc.			inc.		
Rain			st.	inc.			inc.		
Rain Emigrant Springs					dis.				inc.
West Leeville Project									
Northumberland			25,000	29,667	id.				
Olinghouse									
Oliver Hills						exp.	573		
Paradise Peak		st.	188,000	229,100	228,000	198,000	182,000	250,919	156,000
Pinson/Preble/Mag Pit	61,584	63,288	76,634	82,329	72,489	56,382	55,640	50,340	50,867
Preble	17,000	17,500	28,000	18,828	inc.	1,161			
Project Glister					8,450				
Relief Canyon	12,573	11,000	41,600	40,371	30,266	4,100	mo.		
Robertson				st.	3,700				
Robinson	st.	48,000	50,207	57,973	78,828	75,000	21,674	35,581	13,432
Rosebud									exp.un.
Round Mountain (Smoky Valley)	138,748	168,000	190,600	233,700	318,616	483,192	339,024	370,600	374,694
Manhattan	28,303	32,000	24,855	4,752	32,389	inc.			
Ruby Hill									
Ruth Pit									
Santa Fe			st.-	13,484	60,000	64,336	67,102	60,905	54,030
Sleeper	st.	131,333	158,696	230,410	256,219	250,131	183,346	132,383	100,020
Star Pointer		st.	50,000						
Sterling		3,603	9,000	8,427	6,000	12,626	12,215	14,100	14,034

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1985-1993

Mine Names	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Thomas W									
Toiyabe		st.-	7,600	32,000	25,000	11,700	8,780		
Tonkin Springs	2,050	13,740	9,674	565	1,753	2,068		id.	
Trinity					70				
Tripp Pit									
Tuscarora (Dexter)		st.	11,470	7,622	13,932	1,163	id.		
Twin Creeks								st.	482,600
Chimney Creek			st.	200,000	222,556	220,000	228,065	247,969	inc.
Rabbit Creek					st.	25,000	115,500	156,000	inc.
Veteran Pit									
Weepah		30,000	28,000	id.					
Western Hog Ranch	st.	50,000	40,130	28,250	26,280	20,538	18,750	30,000	9,295
White Pine			st.-	4,839	20,654	6,767			
Windfall	2,200		res.	6,380	id.				
Wind Mountain				st.	30,900	81,733	91,063	54,690	19,570
Wood Gulch			st.-	900	19,810	14,926	mo.		
Wright Window		dis.						3,500	
Summation of Identified Production (oz.)	1,239,670	2,084,135	2,703,614	3,676,628	4,992,564	5,828,652	5,800,245	6,561,660	6,832,362
Total State Production (oz.)	1,276,114	2,098,980	2,679,473	3,675,526	4,951,051	5,757,487	5,799,412	6,539,232	6,783,803
Average Gold Price ($/oz.)	318	368	448	438	383	385	363	345	361

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1994-1999

Mine Names	1994	1995	1996	1997	1998	1999	Total Production
Adelaide Crown							4,917
Atlanta							129,120
Aurora-Prospectus	10,500	15,000	10,374	13,284	2,130		126,773
Aurora Partnership	29,971	15,048	7,528				249,495
Austin Gold Ventures							191,000
Bald Mountain	120,000	114,215	107,708	113,547	130,000	105,475	1,164,940
Alligator Ridge	id.		inc.			inc.	605,671
Casino/Winrock						inc.	48,953
Yankee	39,953	36,896				inc.	113,921
Barick Goldstrike Property	1,849,503	2,031,883	1,934,966	1,605,836	1,498,683	1,130,094	14,144,964
Meikle	dev.ug.		78,442	574,308	847,313	977,356	2,477,419
Betze-Post/Goldstrike	inc.						-
Battle Mountain Complex	48,000	74,958	73,100	77,896	36,787	8,322	2,393,629
Copper Canyon							429,918
Fortitude Extension deposit							-
Reona Project	12,000	inc.	inc.	inc.	inc.		12,000
Surprise	mo.						2,000
Big Mike							1,916
Borealis				exp.			554,956
Buckhorn	4,092						202,289
Buckskin-National							539,608
Buffalo Valley				exp.			44,670
Bullfrog-Barrick	301,000	177,631	205,348	206,571	208,123	76,159	2,322,610
Candelaria	12,646	10,720	15,038	9,970	3,006	237	127,324
Coeur Rochester	56,886	59,226	74,293	90,351	88,615	70,396	841,824
Cortez Joint Venture (CJV)	69,608	111,215	160,782	407,973	1,138,725	1,328,525	3,569,772
Cortez Gold							794,661
Cortez Gold/Horse Canyon	inc.	inc.	inc.	inc.	inc.		-
Cresent Pit	dis.						-
Gold Acres/Little Gold Acres							-
Horse Canyon							199,595
Pipeline				inc.		inc.	-
South Pipeline Project	st.	inc.	inc.	inc.			-
Daisy Gold			425	30,524	32,504	30,660	94,113
Dee Gold	24,219	45,000	45,070	39,000	33,156	36,329	623,248
Denton-Rawhide	118,000	117,000	62,269	58,227	123,800	115,900	907,196

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1994-1999

Mine Names	1994	1995	1996	1997	1998	1999	Total Production
Easy Junior Project (Nighthawk Ridge)	p.	14,472	p.	510	po.		26,482
Elder Creek							20,102
Fire Creek							767
Florida Canyon	91,900	111,157	183,176	163,321	152,080	139,590	1,398,152
Flowery (Golden Eagle)	5,080	5,300	2,080	116			23,865
Fondaway Canyon							13,065
Getchell/Turquise Ridge	230,000	167,000	171,343	179,676	175,302	111,000	1,947,716
Gold Bar	6,021	sd.					434,733
Golden Butte							44,755
Goldfield Operation		9,850	3,810	1,376			28,373
Gooseberry							70,850
Green Springs							63,000
Griffon Gold					37,921	24,740	62,661
Hollister (Ivanhoe)	1,080	mo.					112,214
Hycroft (Crofoot/Lewis)	94,868	101,128	89,381	117,379	112,685	40,075	1,100,502
Lewis							8,800
Jerritt Canyon/Savel Canyon	326,667	327,900	309,477	312,015	347,000	363,000	5,512,576
Big Springs (Sammy Creek)	28,315	1,780					416,021
Ken Snyder		dis.			4,357	182,345	186,702
Keystone (Goodsprings)							1,000
Kingston (Sumich)							68,106
Kinsley Mountain	st.	44,040	44,553	38,472	9,543	1,543	138,151
Little Bald Mountain							25,176
Llipah			exp.				14,116
Lone Tree Complex	226,911	227,968	205,738	331,664	257,702	240,091	1,813,090
Marigold	84,895	69,296	73,500	73,640	71,936	74,000	756,326
Mary-Drinkwater							-
Mineral Ridge/Mary-Drinkwater		st.	13,793	13,951	8,582	27,145	63,471
Silver Peak							31,000
McCoy/Cove	359,360	310,016	271,731	187,034	167,494	124,500	3,116,203
Mother Lode/Sunday Night/Anomaly							31,000
Mt. Hamilton		52,000	35,000	37,000	sd.		124,000
Mule Canyon			6,743			55,392	62,135

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1994-1999

Mine Names	1994	1995	1996	1997	1998	1999	Total Production
Newmont Gold Corporation	1,554,000	1,634,483	1,700,033	1,819,115	1,575,391	1,365,866	18,518,618
Blue Star				inc.			54,000
Bootstrap						147,088	147,088
Carlin	dev.un.						2,728,382
Deep Star	st.-	2,800	inc.				2,800
Genesis	id.						58,000
Gold Quarry	inc.	inc.	inc.				871,871
Maggie Creek							-
North Star		st.					-
Post/Deep Post							-
Rain	inc.					23,447	23,447
Rain Emigrant Springs	inc.	inc.	inc.				-
West Leeville Project		inc.	inc.				-
Northumberland							142,779
Olinghouse	dis.				2,912	28,655	31,567
Oliver Hills							573
Paradise Peak	39,084	sd.					1,471,103
Pinson/Preble/Mag Pit	44,000	44,854	42,431	51,600	34,904	11,975	1,099,413
Preble							82,489
Project Glister							8,450
Relief Canyon							164,410
Robertson							3,700
Robinson		res.	39,000	71,820	86,000	26,250	603,765
Rosebud			st.-	93,948	131,703	112,652	338,303
Round Mountain (Smoky Valley)	423,504	344,437	410,977	480,430	510,502	541,808	5,848,707
Manhattan				exp.			168,424
Ruby Hill	dis.	st.	11,600	16,600	116,500	123,841	268,541
Ruth Pit							113,418
Santa Fe	22,361	16,670					358,888
Sleeper	106,912	82,062	38,200	exp.			1,669,712
Star Pointer							50,000
Sterling	13,290	13,000	14,674	4,841	3,970	3,093	132,873

(continued)

Table B-1 (continued)

Gold Production (in ounces) 1994-1999

Mine Names	1994	1995	1996	1997	1998	1999	Total Production
Thomas W							600
Toiyabe							85,080
Tonkin Springs							29,850
Trinity							70
Tripp Pit							38,090
Tuscarora (Dexter)							34,187
Twin Creeks	501,897	451,285	459,083	572,150	871,011	610,728	3,948,754
Chimney Creek	inc.	inc.	inc.	inc.	inc.	inc.	1,118,590
Rabbit Creek	inc.	inc.	inc.	inc.	inc.	inc.	296,500
Veteran Pit							38,090
Weepah							58,000
Western Hog Ranch	7,000	3,000	mo.				233,243
White Pine							32,260
Windfall							93,580
Wind Mountain	10,513	4,296	mo.				292,765
Wood Gulch							35,636
Wright Window							3,500
Summation of Identified Production (oz.)	6,874,036	6,847,586	6,901,666	7,794,145	8,820,337	8,258,277	
Total State Production (oz.)	6,880,255	6,848,104	6,912,405	7,812,626	8,865,000	8,261,000	
Average Gold Price ($/oz.)	385	386	389	332	295	280	281

(continued)

Table B-1 (continued)

Sources:

1. American Mines Handbook 2000 for 1997-98 data
2. Disseminated/Replacement Gold Deposits, 1981, Minobras Mining Services
3. Economic Gold Deposit, 1984, Minobras Mining Services
4. Financial Times, Energy Yearbooks, Mining 1999 p.273-274
5. Gold Discoveries, 1970-1989, Roderick G. Eggert and Alan Casey
6. Gold Guidebook for Nevada and Utah, 1982, Minobras
7. Gold Mines of the World, 1981, Minobras Mining Services
8. Minerals Yearbook USGS.
9. Newmont Gold Company Annual Report and Form 10-K
10. Radol Mining Directory, 1990/91, 1993/94, 1995/96, 1997/98, 1999.
11. Valcanogenic Gold Deposits, 1982, Minibras Mining Services
12. World Gold Vol.I, 1988, Minobras Mining Services
13. 2000/01 Western Mining Directory

Notes:

(1) Newmont Gold Operations (Bootstrap/Capstone, Blue Star, Carlin, Genesis, Gold Quarry and Rain mines) reported production together started 1988.

(2) Average gold price from Engelhard Corporation indusries quotation.

Abbreviations:

dev.	mine development
dev.un.	development underground mining
dis.	discovery gold deposit
exp.	exploration
id.	idle
inc.	production included in the main mine
int.	intermittent production
mo.	mine out
p.	producing or active
po.	phase out
reo.	reopen (during 3-5 years)
res.	resume (less than 3 years)
sd.	shut down mine
st.-	startup mining at the next following year
st	startup mining at the indicated year

Table B-2 Mine Locations and Ownership Data

Name	Location	County	District	Operators	Owners
Adelaide Crown	secs. 24 and 19, 34N-39-40E 1988	Humbolt	Gold Run	Altaur Gold Explorations, Inc.	Altaur Gold Explorations, Inc.
Atlanta	secs. 14 and 15, 7N-68E 1988	Lincoln	Atlanta	Golden Chief Resources, Inc.	Golden Chief Resources, Inc.
Aurora-Prospectus	secs 17-20, 5N-28E 1988	Mineral	Aurora	Real del Monte Mining Corp.	Real del Monte Mining Corp.
Aurora Partnership	secs 17-18, 5N-28E 1994	Mineral	Aurora	Electra Gold Ltd.	Electra Gold Ltd.
Austin Gold Venture	sec. 36, 18N-43E 1988	Lander	Birch Creek	Westgold Inc.	Inspiration Mines & FMC Corp.
Bald Mountain	24N-57E 1999	White Pine	Bald Mountain	Placer Dome North America	Placer Dome U.S.Inc.
Alligator Ridge	sec. 26, 22N-57E 1988	White Pine	Bald Mountain	Placer Dome U.S.Inc.	Placer Dome U.S.Inc.
Casino/Winrock		White Pine	Bald Mountain		
Yankee	24N-57E 1999	White Pine	Bald Mountain		
Battle Mountain Complex	31N-43E 1999	Lander	Battle Mountain	Battle Mountain Gold Co.	Battle Mountain Gold Co.
Copper Canyon	sec. 27, 31N-43E 1981	Lander	Battle Mountain	Duval Corp.	
Fortitude-Extension		Lander	Battle Mountain		
Reona project		Lander	Battle Mountain	Battle Mountain Gold Co.	Battle Mountain Gold Co.
Surprise	secs. 29-30, 32N-44E 1988	Lander	Battle Mountain	Battle Mountain Gold Co.	Battle Mountain Gold Co.
Big Mike	36N-37E	Humbolt	Winnemucca	Ranchers Exploration & Development	
Borealis	secs. 16-17, 6N-29E 1988	Mineral	Hawthorne (Borealis)	Cambior Exploration USA Inc.	Golden Phoenix Minerals, Inc.-Cambior (30-70%)
Buckhorn	secs. 30-31, 27N-49E 1988	Eureka	Buckhorn	Cominco American Resources, Inc.	Cominco American Resources, Inc.
Buckskin-National (leach plant)	45N-39 and 40E	Humbolt	National	Sonora Mining Corp.	Sonora Mining Corp.
Buffalo Valley Gold	sec. 33, 32N-42E 1988	Lander	Buffalo Valley	Fairmile Gold Mining Inc.	Fairmile Gold Mining Inc.
Bullfrog-Barrick	12S-46E 1999	Nye	Bullfrog	Barrick Bullfrog, Inc.	Barrick Gold Corp.
Candelaria	4N-35E 1999	Mineral	Candelaria	Kinross Gold Corp.	Kinross Gold Corp.
Coeur Rochester	28N-34E 1999	Perishing	Rochester	Coeur Rochester, Inc.	Coeur D' Alene Mines Corp.
Cortez Joint Venture (CJV)					
Cortez Gold	27N-47E 1999	Lander	Cortez	Placer Dome Americas (PDA)	Kennecott Mineral Company and
Horse Canyon (Cortez trend)	sec. 3, 27N-48E 1988	Eureka	Cortez	Placer Dome Americas (PDA)	Placer Dome North America (40-60%)
Gold Acres (Cortez trend)	27 and 28N-46 and 47E	Lander	Bullion	Placer Dome Americas (PDA)	
Gold Acres (Cortez)	27N-44E-1981	Lander	Cortez	Placer Dome Americas (PDA)	
Pipeline/South Pipeline	sec. 19, 27N-48E and sec.24, 27N-47E	Lander	Bullion	Cortez Gold Mines	
Daisy Gold	12S-47,48E 1999	Nye	Bare Mountain	Glamis Gold, Ltd.	Glamis Gold, Ltd.
Dee Gold	36 and 37N-49E 1999	Elko	Bootstrap	Glamis Gold, Ltd.	Glamis Gold, Ltd.
Denton-Rawhide (Regent)	13N-32E 1999	Mineral	Rawhide	Kennecott Minerals	Dayton Mining Corp.- Kennecott (49-51%)

(continued)

Table B-2 (continued)

Name	Location	County	District	Operators	Owners
Easy Junior (Nighthawk Ridge)	sec. 9, 15N-56E 1995	White Pine	White Pine	Alta Gold Co.	Alta Bay Joint Venture: Alta and Echo Bay Mines
Elder Creek Project/Shoshone		Lander	Lewis	Alta Gold Co.	Alta-Nerco Joint Venture: Alta and Nerco
Fire Creek	30N-47E	Lander	Bullion	Klondex Mines Ltd.	Klondex Mines Ltd.
Florida Canyon	31, 32N-33E 1999	Perishing	Imlay	Florida Canyon Mining, Inc.,	Apollo Gold, Inc.and Florida Canyon Mining, Inc.
Flowery (Gold Eagle)	sec. 23, 17N-21E 1981	Storey	Flowery	American Eagle Resources Inc.	American Eagle Resources Inc.
Fondaway Canyon	22N-33 and 34E	Churchill	Shady Run	Consolidated Granby Resource Ltd.	Consolidated Granby Resource Ltd.
Getchell	sec.33, 39N-42E 1999	Humbolt	Potosi	Placer Dome North America	Placer Dome North America
Gold Bar	22N-49E 1999	Eureka	Eureka (Antelope)	Atlas Gold Mining, Inc.	Atlas Corp.
Golden Butte	secs. 10 and 15, 23N-61E 1988	White Pine	Cheery Creek	Alta Bay Joint Venture	Alta Gold and Echo Bay Mining Co. (60-40)
Goldfield project	sec. 35-36, 2S-42E 1980	Esmeralda	Goldfield	American Resources Corp.	American Resources Corp.
Goldstrike Property					
Betze-Post	36N-49, 50E 1999	Eureka	Lynn	Barrick Goldstrike Mines,Inc.	Barrick Gold Corp.
Meikle (Purple Vein)	36N-50E 1999	Elko	Lynn	Barrick Goldstrike Mines, Inc.	Barrick Gold Corp.
Goosebery	sec.25, 19N-22E 1981 (add)	Storey	Goosebery	Pallas Resources Corp.	Pallas Resources Corp.
Green Springs	sec. 33, 15N-57E 1988	White Pine	?		
Griffon	14N-58E 1999	White Pine	White Pine	Atla Gold Co.	Atla Gold Co.
Hollister (Ivanhoe)	sec. 4, 38N-48E 1988	Elko	Bootstrap	Great Basin Gold	Great Basin Gold-Cornucopia Resources (75-25%)
Hycroft (Lewis & Crofoot)	35N-29, 30E 1999	Humbolt	Sulphur	Hycroft Resources & Develop., Inc.	Vista Gold Corp.
Hycroft (Crofoot)	35N-29, 30E 2000	Humbolt	Sulphur		
Jerritt Canyon Joint Venture	39-41N-52-54E 1999	Elko	Independence Mt.	AngloGold (Jerritt Canyon) Corp.	AngloGold North America, Inc. and
Big Springs (Sammy Creek?)	sec.2.11 and 12, 42N-53E 1988	Elko	Independence Mt.	Independence Mining Company, Inc.	Meridian Gold, Inc.(70-30%)
Ken Snyder	39N-46E 1999	Elko	Gold Circle	Euro-Nevada	Franco-Nevada and Euro-Nevada (50-50%)
Keystone (Goodsprings)	24S-57 and 58E	Clark	Goodsprings	Durvada Resources	Keystone Barefoot Mines Co.
Kingston (Victorine, Sumich)	sec. 22, 16N-43E 1988	Lander	Kingston		
Kinsley Mountain	26N-68E 1999	Elko	Kinsley	Alta Gold Co.	Alta Gold Co.
Little Bald Mountain	secs. 27 and 34, 24N-57E 1988	White Pine	Bald Mountain	Northern Dynasty Exploration Ltd.	
Lllipah	sec. 4, 18N-58E 1988	White Pine	Lllipah	Echo Bay Mines Inc.	Echo Bay Mines Inc.
Lone Tree Complex (NGC)	34N-42E 1999	Humbolt	Battle Mountain	Newmont Mining Corp.	Newmont Mining Corp.
Marigold	sec. 18, 33N-43E 1999	Humbolt	Gold Run (Battle Mnt.)	Glamis Gold, Inc.	Glamis Gold, Inc.- Homestake (66.7-33.3%)
Mineral Ridge	2S-38-39E 1999	Esmeralda	Silver Peak	Mineral Ridge Resources, Inc.	Vista Gold Corp.
McCoy	sec 2, 28-29N-42E 1999	Lander	McCoy	Echo Bay Mines. Ltd.	Echo Bay Mines. Ltd.
McCoy (Cove)	sec. 36, 28-29N-42E 1999	Lander	McCoy		
Mother Lode		Nye	Beatty	Gexa Gold Corp.	
Mountain Halminton	16N-58E	White Pine	White Pine	Mountain Hamilton Mining Co.	Mountain Hamilton Mining Co.
Mule Canyon (NGC)	32N-47E 1999	Lander	Argenta	Newmont Mining Corp.	Newmont Mining Corp.

(continued)

Table B-2 (continued)

Name	Location	County	District	Operators	Owners
Newmont Gold Corporation					
Blue Star	sec.4, 35N-50E 1981	Eureka	Lynn	Newmont Mining Corp.	Newmont Mining Corp.
Bootstrap	sec. 8, 36N-49 and 50E 1981	Elko	Bootstrap	Newmont Mining Corp.	Newmont Mining Corp.
Carlin	secs. 14-15, 35N-50E 1981	Eureka	Eureka	Newmont Mining Corp.	Newmont Mining Corp.
Deep Star	36N-50E	Elko	Lynn	Newmont Mining Corp.	Newmont Mining Corp.
Genesis	E1/2, sec. 31, 36N-50E 1988	Eureka	Lynn	Newmont Mining Corp.	Newmont Mining Corp.
Gold Quarry	sec. 35, 34N-51E 1981	Eureka	Maggie Creek	Newmont Mining Corp.	Newmont Mining Corp.
Maggie Creek	secs. 26 and 35, 34N-51E 1981	Eureka	Maggie Creek	Newmont Mining Corp.	Newmont Mining Corp.
North Star	36N-50E	Eureka	Lynn	Newmont Mining Corp.	Newmont Mining Corp.
Post/Deep Post	S1/2 sec. 19, 36N-50E 1988	Eureka	Lynn	Barrick and Newmont	Newmont Mining Corp.
Rain	sec. 33, 32N-53E 1988	Elko	Bootstrap	Newmont Mining Corp.	Newmont Mining Corp.
Rain Emmigrant Springs	2 miles northeast in sec. 35 1988	Elko	Carlin	Newmont Mining Corp.	Newmont Mining Corp.
Northumberland	sec. 18, 13N-46E 1988	Nye	Northumberland	Western States Minerals Corp.	Western States Minerals Corp.
Olinghouse	21N-23E 1999	Washoe	Olinghouse	Alta Gold Co.	Alta Gold Co.
Over Hills		Storey	Comstock		
Paradise Peak (Ketchup Flats pit)	sec. 4, 10N-36E 1988	Nye	Fairplay	Arimetco Paradise Peak Corp.	Arimetco Inc.
Pinson	sec. 32, 38N-42E 1999	Humbolt	Potosi	Homestake Mining Co.	Barrick Gold Corp.and Homestake (50-50%)
Preble	36N-40E	Humbolt	Potosi		
Relief Canyon	sec. 16, 27N-34E 1988	Perishing	Antelope	Newgold, Inc.	Newgold, Inc.
Robertson (Cortez trend)	sec. 8, 28N-47E 1988	Lander	Bullion	Coral Gold Corp.	Coral Gold Corp.
Robinson	16N-62E 1999	White Pine	Robinson	BHP Nevada Mining Co.	BHP Copper North America
Rosebud	34N-29, 30E 1999	Perishing	Rosebud	Newmont (mill), Hecla Mining Co.(mine)	Hecla Mining Co.- Newmont (50-50%)
Round Mountain (Smoky Valley)	secs 19 and 30, 10N-44E 1999	Nye	Round Mountain	Echo Bay Mines	Echo Bay Mines. Ltd.- Homestake (50-50%)
Manhattan	secs 18-19, 10N-44E, 1981	Nye	Round Mountain	Houston International Minerals Inc.	and Case Pomeroy (50, 25, 25%)
Ruby Hill	19N-53E 1999	Eureka	Eureka	Homestake Mining Co.	Homestake Mining Co.
Ruth Pit	16N-62E	White Pine	Robinson	Kennecott Copper Corp.	
Santa Fe	sec. 36, 9N-34E 1988	Mineral	Santa Fe	Corona Gold, Inc.	
Sleeper	secs 16 and 21, 40N-35E 1988	Humbolt	Awakening	Kinross Gold Corp.	Kinross Gold Corp.
Star Pointer	sec. 15, 16N-62E 1988	White Pine	Robinson		
Sterling	sec. 13, 13S-48E 1999	Nye	Bare Mountain	Cathedral Gold U.S. Corp.	Cathedral Gold U.S. Corp.- Albany Gold (50-50%)

(continued)

Table B-2 (continued)

Name	Location	County	District	Operators	Owners
Thomas "W"	sec. 9, 20N-40E (add) 1981	Lander	New Pass	Reorganized Silver King Divide Mining Co.	
Toiyable (Cortez trend)	sec 18, 25N-46 and 47E 1988	Lander	Cortez		
Tonkin Springs (Cortez trend)	secs 2 and 3, 23N-49E 1988	Eureka	Antelope	Sudbury Contact Mining	U.S.Gold Corp. and Sudbury (40-60%)
Tuscarora (Dexter)	NE1/4 sec.3, 39N-51E 1988	Elko	Tuscarora	Newcrest Resources Inc.	Newcrest Resources Inc.
Twin Creeks	39N-43E 1999	Humbolt	Potosi	Newmont Mining Corp.	Newmont Mining Corp.
Chimney Creek	secs 5 and 32, 39-40N-43E 1988	Humbolt	Potosi	Gold Fields Mining Corps	
Rabbit Creek		Humbolt	Potosi		
Veteran		White Pine	Robinson	Kennecott Copper Corp.	
Weepah	sec. 20, 1N-40E 1988	Esmeralda	Weepah	Weepah Nevada Mining Co.	
Western Hog Ranch	sec. 24, 38N-22E 1988	Washoe	Gerlach	Royaledge Resources Inc.	Royaledge Resources Inc.
White Pine		White Pine	White Pine	Western States Minerals Corp.	Western States Minerals Corp.
Windfall	sec. 2, 18N-53E 1981	Eureka	Eureka	Idaho Mining Co.	
Wind Mountain		Washoe	?	Wind Mountain Mining, Inc.	Amex Gold Inc.
Wright Window		Elko	Independence Mt.		

Sources:

1. American Mines Handbook 2000 for 1997-98 data
2. Disseminated/Replacement Gold Deposits, 1981, Minobras Mining Services
3. Economic Gold Deposit, 1984, Minobras Mining Services
4. Financial Times, Energy Yearbooks, Mining 1999 p.273-274
5. Gold Discoveries, 1970-1989, Roderick G. Eggert and Alan Casey
6. Gold Guidebook for Nevada and Utah, 1982, Minobras
7. Gold Mines of the World, 1981, Minobras Mining Services
8. Minerals Yearbook USGS.
9. Newmont Gold Company Annual Report and Form 10-K
10. Radol Mining Directory, 1990/91, 1993/94, 1995/96, 1997/98, 1999.
11. Valcanogenic Gold Deposits, 1982, Minibras Mining Services
12. World Gold Vol.I, 1988, Minobras Mining Services
13. 2000/01 Western Mining Directory

Table B-3 Mining and Geological Data

Name	Category	Current Mine Type	Deposit Type	Ore Classification	Processing	Note
Adelaide Crown	mine	open pit	cavity-fillings	silver-gold	heap leaching/Merrill Crowe	
Atlanta	mine	open pit	disseminated	silver-gold	mill	
Aurora-Prospectus	mine	open pit-und.	replacements	silver-gold	heap leaching/CIL/mill	drilling
Aurora Partnership	mine	open pit	replacements	silver-gold	heap leaching	
Austin Gold Venture	mine	open pit	disseminated	gold	flotation/CIL	
Bald Mountain	mine	open pit	disseminated	gold	heap leaching	
Alligator Ridge	mine	open pit	disseminated	gold	heap leaching	in closure
Casino/Winrock	mine	open pit	disseminated	gold	heap leaching	
Yankee	mine	open pit	disseminated	gold	heap leaching	
Battle Mountain Complex (Fortitude)	mine	open pit	disseminated	gold-silver	heap leaching/CIP	
Copper Canyon	mine	open pit	cavity-fillings	copper	heap leaching	
Fortitude-Extension	mine	open pit	disseminated	gold	heap leaching	
Reona project	mine	open pit	disseminated	gold-silver	heap leaching	
Surprise	mine	open pit	disseminated	gold	heap leaching	
Big Mike	mine	open pit	cavity-fillings	copper	flotation	
Borealis	mine	underground	disseminated	silver-gold	heap leaching/CIL/Merrill Crowe	
Buckhorn	mine	open pit	cavity-fillings	silver-gold	heap leaching/Merrill Crowe	
Buckskin-National	mine	underground	cavity-fillings	silver-gold	flotation/cyanidation/CIP	
Buffalo Valley Gold	mine	open pit	disseminated	gold	heap leaching	
Bullfrog-Barrick	mine	underground	cavity-fillings	gold-silver	milling/CIL	reclamation
Candelaria	mine	open pit	replacements	silver-gold	heap leaching/Merrill Crowe	
Coeur Rochester	mine	open pit	cavity-fillings	silver-gold	heap leaching/Merrill Crowe	
Cortez Joint Venture (CJV)					heap leaching/CIL	
Cortez Gold	mine	open pit	replacements	gold-silver	heap leaching/circulating/CIL and	
Horse Canyon (Cortez trend)	mine	open pit	replacements	gold	fluid-bed roaster	depleted
Gold Acres (Cortez trend)	mine	open pit	disseminated	gold		mined later
Gold Acres (Cortez)	mine	open pit	disseminated	gold		
Pipeline/South Pipeline	mine	open pit	disseminated	gold		mining
Daisy Gold	mine	open pit	disseminated	gold	heap leaching	reclamation
Dee Gold	mine	open pit-und.	disseminated	gold	heap leaching/CIL	
Denton-Rawhide (Regent)	mine	open pit	replacements	gold-silver	heap leaching/Merrill Crowe	

(continued)

Table B-3 (continued)

Name	Category	Current Mine Type	Deposit Type	Ore Classification	Processing	Note
Easy Junior (Nighthawk Ridge)	mine	open pit	disseminated	gold-silver	heap leaching	
Elder Creek Project/Shoshone	mine	open pit	disseminated	gold	heap leaching	
Fire Creek	mine	open pit	disseminated	gold-silver	heap leaching	
Florida Canyon	mine	open pit	replacements	gold-silver	heap leaching/carbon ad./Merrill Crowe	
Flowery (Gold Eagle)	mine	open pit	cavity-fillings	silver-gold	heap leaching/Merrill Crowe	reclamation
Fondaway Canyon	mine	open pit	cavity-fillings	silver-gold	heap leaching	
Getchell	mine	underground	replacements	gold	autoclaving/CIL/Merrill Crowe/milling	
Gold Bar	mine	open pit	disseminated	gold	CIL/CIP/autoclaving	
Golden Butte	mine	open pit	disseminated	gold-silver	heap leaching	
Goldfield project	mine	open pit	replacements	gold	heap leaching	
Goldstrike Property						
Betze-Post	mine	open pit	disseminated	gold	carbon leach/autoclaving/milling	
Meikle (Purple Vein)	mine	underground	cavity-fillings	gold	carbon leach/cyanide/autoclaving	
Goosebery	mine	underground	cavity-fillings	silver-gold	flotation	
Green Springs	mine	open pit	disseminated	gold		
Griffon	mine	open pit	disseminated	gold-silver	heap leaching	
Hollister (Ivanhoe)	mine	open pit	disseminated	gold	heap leaching	
Hycroft (Lewis & Crofoot)	mine	open pit	cavity-fillings	gold-silver	heap leaching pad/crushing	
Hycroft (Crofoot)	mine	open pit	cavity-fillings	gold-silver	heap leaching pad/Merrill Crowe	
Jerritt Canyon JV	mine	open pit-und.	cavity-fillings	gold	fluid-bed roaster/CIL/CIP/heap leaching	
Big Springs (Sammy Creek)	mine	underground	cavity-fillings	silver-gold	heap leaching/CIL/roaster	ceased 10/94
Ken Snyder	mine	underground	cavity-fillings	silver-gold	milling/cyanide leach/Merrill Crowe	
Keystone (Goodsprings)	mine	open pit	replacements	base-metal	heap leaching	
Kingston (Victorine, Sumich)	mine	underground	cavity-fillings	silver-gold		
Kinsley Mountain	mine	open pit	disseminated	gold-silver	heap leaching	
Little Bald Mountain	mine	open pit	disseminated	gold	heap leaching	
Llipah	mine	open pit	disseminated	gold		
Lone Tree Complex (NGC)	mine	open pit	disseminated	gold	oxide milling/heap leaching/flotation	
Marigold	mine	open pit	disseminated	gold-silver	heap leaching/CIL/columns	
Mineral Ridge	mine	open pit	cavity-fillings	gold-silver	heap leaching	ceased 12/99
McCoy	mine	open pit	cavity-fillings	silver-gold	heap leaching/milling	
McCoy (Cove)	mine	open pit	disseminated	gold	heap leaching/milling	
Mother Lode	mine		cavity-fillings			
Mountain Halminton	mine	open pit	replacements	gold-silver	heap leaching/columns	
Mule Canyon (NGC)	mine	open pit	disseminated	gold	autocalving/heap leaching/floatation	

(continued)

Table B-3 (continued)

Name	Category	Current Mine Type	Deposit Type	Ore Classification	Processing	Note
Newmont Gold Corporation					bioleaching/heap leaching/roasting	
Blue Star	mine	open pit	disseminated	gold	agitated leaching/CIL	mill 1
Bootstrap	mine	open pit	disseminated	gold	agitated and dump leaching/CIL	mill 4
Carlin	mine	open pit-und.	disseminated	gold	agitated leaching/CIL	mill 1
Deep Star	mine	open pit	disseminated	gold		
Genesis	mine	open pit	disseminated	gold	agitated leaching/CIL	mill 1
Gold Quarry	mine	open pit	disseminated	gold	heap leaching	
Maggie Creek	mine	open pit	disseminated	gold	heap leaching	
North Star	mine	open pit	disseminated	gold		
Post/Deep Post	mine	open pit	disseminated	gold	heap leaching	
Rain	mine	underground	disseminated	gold	cyanide leach	
Rain Emmigrant Springs	mine	open pit	disseminated	gold	cyanide leach	
Northumberland	mine	open pit	disseminated	gold	heap leaching	exploration
Olinghouse	mine	open pit	cavity-fillings	gold-silver	heap leaching/gravity seperation	
Over Hills	mine		cavity-fillings	silver-gold		
Paradise Peak (Ketchup Flats pit)	mine	open pit	replacements	silver-gold	heap leaching/CIL	
Pinson	mine	open pit	disseminated	gold	heap leaching/CIL	in closure
Preble	mine	open pit	disseminated	gold	heap leaching/CIL	
Relief Canyon	mine	open pit	disseminated	gold-silver	heap leaching	
Robertson (Cortez trend)	mine	open pit	replacements	gold		
Robinson	mine	open pit	replacements	copper-gold	milling/flotation	
Rosebud	mine	underground	cavity-fillings	silver-gold	heap leaching/CIL	exploration
Round Mountain (Smoky Valley)	mine	open pit	replacements	gold-silver	heap leaching	
Manhattan	mine	open pit-und.	disseminated	gold	heap leaching	exploration
Ruby Hill	mine	open pit	disseminated	gold	heap leaching	
Ruth pit	mine	open pit	replacements	copper	flotation	
Santa Fe	mine	open pit	disseminated	gold-silver	heap leaching	
Sleeper	mine	open pit	cavity-fillings	silver-gold	heap leaching/milling	
Star Pointer	mine	open pit	disseminated	silver-gold		
Sterling	mine	underground	disseminated	gold	heap leaching/carbon columns	

(continued)

Table B-3 (continued)

Name	Category	Current Mine Type	Deposit Type	Ore Classification	Processing	Note
Thomas "W"	mine		cavity-fillings	silver-gold	heap leaching	
Toiyable (Cortez trend)	mine		disseminated	gold-silver		
Tonkin Springs (Cortez trend)	mine	open pit	replacements	gold	bioleaching-first mine/CIL	exploration
Tuscarora (Dexter)	mine	open pit	cavity-fillings	silver-gold		
Twin Creeks	mine	open pit	replacements	gold	autocalving/milling/heap leaching	
Chimney Creek	mine	open pit	replacements	gold	milling/heap leaching/CIP/CIL	
Rabbit Creek	mine	open pit	replacements	gold	milling/heap leaching	
Veteran	mine	open pit	replacements	copper	flotation	
Weepah	mine	open pit	cavity-fillings	silver-gold		
Western Hog Ranch	mine	open pit	disseminated	gold		
White Pine	mine	open pit	replacements	gold		closure
Windfall	mine	open pit	replacements	gold	heap leaching	
Wind Mountain	mine	open pit		silver-gold	heap leaching/Merill-Crowe	
Wright Window	mine		cavity-fillings			

Sources:

1. American Mines Handbook 2000 for 1997-98 data
2. Disseminated/Replacement Gold Deposits, 1981, Minobras Mining Services
3. Economic Gold Deposit, 1984, Minobras Mining Services
4. Financial Times, Energy Yearbooks, Mining 1999 p.273-274
5. Gold Discoveries, 1970-1989, Roderick G. Eggert and Alan Casey
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10. Radol Mining Directory, 1990/91, 1993/94, 1995/96, 1997/98, 1999.
11. Valcanogenic Gold Deposits, 1982, Minibras Mining Services
12. World Gold Vol.I, 1988, Minobras Mining Services
13. 2000/01 Western Mining Directory

Table B-4 Discovery and Reserve Data

Mine Names	Discovery Year	Startup Production and Operating Years	Recovery (oz.)	Mined Grade (oz./ short ton)	Reserve-Year (short ton)	Grade Reserve (oz./ short ton)
Adelaide Crown	1986	1932-, 1940-42, 1981-, 1988-, 1990-91		0.06Au	0.7m-1989	0.015-0.043Au
Atlanta	1975	1975-84	150,000	0.08Au, 1.6Ag		
Aurora-Prospectus	1860, 1981	1863-, 1983-85, 1988-98		0.14Au	2m-2000	0.1Au
Aurora Partnership	1983	1930s, 1983, 1987-96			0.23m-1995	0.208Au
Austin Gold Venture	1981	1986-89		0.13Au	1.2m-1988	0.19Au
Bald Mountain	1982	1986-p		0.05Au		
Alligator Ridge	1976	1981-93, 1996-p		0.09Au	11.5m-1992	0.046Au
Casino/Winrock		1990-93, 1999			0.8/1.3m-1989	0.054Au/0.037Au
Yankee		1991-95, 1999				
Battle Mountain Complex		1979-p		0.23Au	52.9m-1996	0.038Au
Copper Canyon	1866, 1965	1897-, 1931-54, 1967-p	48,000	0.1-0.5Au	4m	0.09Ag, 0.28Ag
Fortitude and Extension	1981, 1992	1984-p		0.15Au, 0.57Ag	16m	
Reona project	1989	1994-98		0.022Au	5.9m-2000	
Surprise	1987	1987-91		0.12Au, 1.1Ag	0.7m	
Borealis	1970s, 1980	1981-90		0.06Au, 0.5Ag	0.96m-1997	0.24Au
Buckhorn	1908, 1990	1914-16, 1936-41, 1984-94		0.12Au, 1.4Ag	1.1m-1993	0.11Au
Buckskin-National	1907,	1932-41, 1989-93				
Buffalo Valley Gold	1984	1987-90		0.08Au	4.8m-1994	0.07Au
Bullfrog-Barrick	1904, 1987	1907-, 1989-p		0.2Au	10.2m-1996	0.062Au
Candelaria	1979	1982, 1986-99			1.4m-1996	0.005Au, 1.76Ag
Coeur Rochester	1984	1986-p				
Cortez Joint Venture (CJV)						
Cortez Gold	1965	1969-76		0.072Au	107m-2000	
Horse Canyon (Cortez trend)	1976, 1981	1983-88, 1993		0.05Au	3.94m-1984	0.055Au
Gold Acres (Cortez trend)	1930, 1976, 1980, 1985	1935-1961, 1974-76, 1986-91	300,000	0.06-0.3Au	1.6m	0.019Au
Pipeline/South Pipeline	1992	1995-97			159m-1999	0.052Au
Daisy Gold	1993	1996-p			4.2m-1998	0.033Au
Dee Gold	1980	1984-p		0.055Au	1.9m-1998	0.155Au
Denton-Rawhide (Regent)	1906, 1983	1908-1935, 1990-p	51,000		24m-1988	0.045Au, 0.47Ag

(continued)

Table B-4 (continued)

Mine Names	Discovery Year	Startup Production and Operating Years	Recovery (oz.)	Mined Grade (oz./ short ton)	Reserve-Year (short ton)	Grade Reserve (oz./ short ton)
Easy Junior (Nighthawk Ridge)	1986	1989-90, 1994-97			5.68m-1989	0.031Au
Elder Creek Project/Shoshone	1989	1990-91			1.5m-1990	0.041Au
Fire Creek	1982	1983-84			0.35m-1982	0.06Au
Florida Canyon	1980	1986-p		0.024Au	45.5m-1997	0.024Au
Flowery (Gold Eagle)	1978	1988, 1990, 1992-97			0.36m-1993	0.064Au, 0.97Ag
Fondaway Canyon	1988	1989-90		0.06Au	0.4m-1990	0.06Au
Getchell	1934, 1985	1936-45, 1948-50, 1956-66, 1985-p	800,000	0.16Au	18.4m-2000	0.345Au (av.)
Gold Bar	1983	1987-94		0.09Au	2.8m-1988	0.10Au
Golden Butte	1981	1989-93			4.23m-1989	0.031Au
Goldfield project	1983	1903-45, 1989, 1993, 1995-97		0.07Au	3.5m-1994	0.071Au
Goldstrike Property						
Betze-Post	1975, 1985	1980-p		0.27Au	123m-1998	0.172Au
Meikle (Purple Vein)	1990, 1992	1996-p			6.6m-1998	0.713Au
Goosebery	1906, 1960s	1960s, 1977-80, 1983-85, 1988-91	15,000	0.14Au, 7.2Ag	0.6m	
Green Springs		1988-91		0.06Au	1.2m-1988	0.06Au
Griffon	1993	1998-99		0.026Au	3.8m-1999	0.025Au
Hollister (Ivanhoe)	1983	1990-94		0.03Au	53m	
Hycroft (Lewis & Crofoot)	1981, 1984	1984, 87-p		0.03Au	25.2m-1997	0.02Au
Jerritt Canyon JV	1976	1982-p		0.22Au	2.1m-1997	0.269Au
Big Springs (Sammy Creek)	1985	1987-95		0.17Au	1.55m-1989	0.172Au
Ken Snyder	1995	1998-p		0.86Au, 9.8Ag	3m-2000	0.816Au, 9.835Ag
Keystone (Goodsprings)	1982, 1990	1902-47, 1990	22,000		0.11m-1992	0.11Au
Kingston (Victorine, Sumich)	1862	1938-39, 1987-90		0.17Au	0.25m-1995	0.36Au
Kinsley Mountain	1988	1995-p			3.4m-1996	0.032Au
Little Bald Mountain	1984	1985-92		0.1Au	0.14m-1993	0.13Au
Lllipah	1985	1986-89			1m-1988	0.03Au
Lone Tree Complex (NGC)	1989	1991-p		0.063Au	36.6m-2000	0.025-0.159Au
Marigold	1985	1941, 1989-p		0.032Au	12.7m-2000	0.032Au
Mineral Ridge	1995	1996-99		0.06au	4m-1998	0.06Au
McCoy	1914, 1981	1986-p		0.06Au, 1.09Ag	63.3m-1993	0.037Au, 1.66Ag
McCoy (Cove)	1987	1988-p		0.06Au, 2.8Ag	34m	
Mother Lode	1987	1989-90				
Mountain Halminton	1800s, 1985	1995-97			7.2m-1997	0.035Au
Mule Canyon (NGC)	1992	1996, 1999			9m-1996	0.112Au

(continued)

Table B-4 (continued)

Mine Names	Discovery Year	Startup Production and Operating Years	Recovery (oz.)	Mined Grade (oz./ short ton)	Reserve-Year (short ton)	Grade Reserve (oz./ short ton)
Newmont Gold Corporation						
Blue Star	1968	1974-84, 1987-97		0.09Au-0.15Au	22.2m-1989	0.03Au
Bootstrap	1867, 1969	1950s, 1975-82, 1988-91, 1999	30,000	0.15-0.18Au		
Carlin	1962	1965-p	4.3m	0.29Au-0.17Au	11m-1965	0.32Au
Deep Star		1974, 1995-96			1.4m-1996	0.876Au
Genesis	1985	1987-94			32m-1990	0.047Au
Gold Quarry	1979, 1983	1985-96			212m-1990	0.042Au
Maggie Creek	1977	1981-86		0.15Au	11m	0.03Au
North Star		1988, 1995			3.9m-1990	0.052Au
Post/Deep Post	1982	1988-91		0.501Au	1.3m-2000	
Rain	1980	1987-94, 1999		0.026Au	13m-2000	0.06Au
Rain Emmigrant Springs	1989	1993-96		0.02Au	16m-1996	0.028Au
Northumberland	1972	1939-42, 1981-84, 1987-88	33,000	0.07Au	12m-1988	0.06Au
Olinghouse	1994	1998-99			12m-1997	0.042Au
Over Hills	1990	1991			4m-1993	0.05Au, 0.5Ag
Paradise Peak (Ketchup Flats pit)	1984	1987-1994		0.1Au, 3.5Ag	5m-1996	0.022Au, 0.2Ag
Pinson	1949, 1971, 1979	1949, 1980-p		0.028Au	2.6m-1996	0.072Au
Preble	1972	1949, 1985-90		0.06Au	1.7m	0.079Au
Relief Canyon	1983	1984-90		0.03Au	8.6m-1996	0.022Au
Robertson (Cortez trend)	1988	1989		0.04Au	11m-1988	0.04Au
Robinson	1980	1986-93, 1996-p			252m-1994	0.553%Cu, 0.01Au
Rosebud	1906	1997-p			0.48m-1998	0.392Au, 1.8Ag
Round Mountain (Smoky Valley)	1906	1977-p		0.06Au	401.3m-1997	0.018Au
Manhattan	1972	1906-, 1983-90		0.06Au		
Ruby Hill	1994	1996-99		0.11Au	3.7m-2000	0.098Au
Ruth pit	1902	1908-, 1970-78	3,000,000	0.0076Au		
Santa Fe (Hidden Treasure)	1983	1989-95		0.04Au, 0.39Ag	6.8m-1990	0.035Au, 0.24Ag
Sleeper	1984	1986-1996		0.38Au	182m-1998	0.042Au
Star Pointer	1981	1987		0.09Au	2.2m-1988	0.09Au
Sterling	1973	1986-p		0.22Au	0.2m-1996	0.245Au

(continued)

Table B-4 (continued)

Mine Names	Discovery Year	Startup Production and Operating Years	Recovery (oz.)	Mined Grade (oz./ short ton)	Reserve-Year (short ton)	Grade Reserve (oz./ short ton)
Thomas "W"	1864	1936-, 1980				
Toiyable (Cortez trend)	1970	1987-91		0.07Au	0.8m-1988	0.066Au
Tonkin Springs (Cortez trend)	1980	1985-90		0.09Au	9.8m-1996	0.056Au
Tuscarora (Dexter)	1867, 1987	1896-1902, 1987-90	29,940	0.08Au, 1.5Ag	1.8m-1988	0.037Au-0.74Ag
Twin Creeks		1993-p		0.079Au	87m-2000	
Chimney Creek	1985	1988-p		0.06Au	27m-1988	0.068Au
Rabbit Creek	1987	1990-p				
Weepah	1930, 1984	1935-39, 1986-87		0.1Au, 0.4Ag	0.2m-1986	0.1Au, 0.4Ag
Western Hog Ranch	1981	1986-95		0.05Au	5m-1988	0.03Au
White Pine		1988-90				
Windfall	1968, 1986	1976-85, 1988		0.04Au	3m-1976	0.035Au
Wind Mountain	1978	1989-95				
Wright Window	1986	1992			1.3m-1986	0.095Au

Sources:

1. American Mines Handbook 2000 for 1997-98 data
2. Disseminated/Replacement Gold Deposits, 1981, Minobras Mining Services
3. Economic Gold Deposit, 1984, Minobras Mining Services
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12. World Gold Vol.I, 1988, Minobras Mining Services
13. 2000/01 Western Mining Directory

APPENDIX C

CLASSIFICTION OF DEVELOPMENT TYPES AND LEAD TIME

Table C-1 Classification of Development Types

Related Discovery Development Type

	Name	Discovery Year	Startup Year	Recorded Years of Production	Lead Time	Total Production
1	Adelaide Crown mine	1986	1990	1990-91	4	4,917
2	Aurora open pit mine s-1863, 1987	1981	1983	1983-98	2	126,773
3	Aurora Partnership mine s-1987	1983	1987	1987-96	4	249,495
4	Austin Gold Ventures	1981	1986	1986-89	5	191,000
5	Bald Mountain mine s-1986	1982	1986	1986-	4	1,164,940
6	Casino/Winrock mines s-1990		1990	1990-	<5	48,953
7	Yankee s-1991		1991	1991-	<5	113,921
8	Reona Project (Battle Mnt.)	1989	1994	1994-	5	12,000
9	Surprise mine (Battle Mnt.)	1984	1987	1987-91	3	2,000
10	Borealis mine	1980	1981	1981-91	1	554,956
11	Buckhorn mine s-1984	1980	1984	1984-94	4	202,289
12	Buffalo Valley Gold mine	1984	1987	1987-90	3	44,670
13	Bullfrog s-1907	1987	1989	1989-	2	2,322,610
14	Horse Canyon	1981	1983	1983-	2	199,595
15	Gold Acres and Little Gold Acres		1974	1974-91		
16	Daisy Gold mine s-1996	1993	1996	1996-	3	94,113
17	Dee Gold mine (Carlin trend) s-1984	1980	1984	1984-	4	623,248
18	Fire Creek-Klondex mine	1982	1983	1983-84	1	767
	Goldstrike Property					
19	Betze-Post mine s-1979	1974	1979	1979-	5	14,144,964
20	Meikle (Purple Vein)	1992	1996	1996-	4	2,477,419
21	Green Springs mine		1988	1988-91	<5	63,000
22	Hycroft mine (Crofoot and Lewis) s-1988 and 84	1984	1987	1987-	3	1,100,502
23	Ken Snyder mine-Midas JV	1995	1998	1998-	3	186,702
24	Little Bald Mountain open pit mine (Placer Dome 65%)	1984	1985	1985-92	1	25,176
25	Lone Tree Complex s-1991 (NGC)	1989	1991	1991-	2	1,813,090
26	Marigold mine s-1989	1985	1989	1989-	4	756,326
27	McCoy/Cove mine s-1986/88	1981	1986	1986-	5	3,116,203
28	Mother Lode (incl. Sunday Night and Anomaly)	1987	1989	1989-93	2	31,000
29	Newmont Gold Corporation (NGC)					18,518,618
30	Blue Star (Carlin trend) s-1974	1968	1974	1974-	6	54,000
31	Bootstrap/Capstone	1969	1974	1974-	5	147,088
32	Deep Star ug mine s-1995		1995	1995-		2,800
33	Genesis (Carlin trend) s-1987	1985	1987	1987-	2	58,000
34	Gold Quarry (Carlin trend) s-1985	1983	1985	1985-	2	871,871
35	Maggie Creek mine (Carlin trend) s-1985	1977	1981	1981-88	4	-
36	North Star (Carlin trend)		1988	1988-95		-
37	Post and Deep Post (Carlin trend) d-1982,86	1982	1988	1988-	6	-
38	Rain Emigrant Springs	1989	1993	1993-	4	-
39	Project Glister		1989	1989-90	<5	8,450
40	Robertson mine s-1989	1988	1989	1989-90	1	3,700
41	Tonkin Springs mine	1980	1985	1985-92	5	29,850
42	Twin Creeks mine (NGC)	1985	1987	1993-	2	3,948,754
43	Chimney Creek mine	1985	1988	1988-	3	1,118,590
44	Rabbit Creek s-1990	1987	1990	1990-	3	296,500
45	White Pine mine s-1989		1988	1988-90	<5	32,260
46	Wood Gulch		1989	1989-91	<5	35,636
				Total (group)	46 mines	54,796,746

(continued)

Table C-1 (continued)

Greenfield Development Type

	Name	Discovery Year	Startup Year	Recorded Years of Production	Lead Time	Total Production
1	Atlanta open pit mine	1975	1975	1975-84	0	129,120
2	Alligator Ridge mine s-1980, 90	1976	1981	1981-	5	605,671
	Battle Mountain Complex					2,393,629
3	Copper Canyon mine (Called Battle Mountain in 1979)	1965	1967	1967-	2	429,918
	Fortitude (adjacent Battle Mnt.)	1981	1985	1985-	4	
4	Fortitude Extension deposit	1992	1992	1992-93	0	
5	Big Mike mine			1970-		1,916
6	Cortez Joint Venture					3,569,772
7	Cortez Gold mine	1965	1969	1969-	4	794,661
8	Easy Junior Project (Nighthawk Ridge)	1986	1989	1989-97	3	26,482
9	Elder Creek Project/Shoshone mines	1989	1990	1990-91	1	20,102
10	Fondaway Canyon mine	1988	1989	1989-90	1	13,065
11	Gold Bar mine s-1986 (Barrick 1997)	1983	1987	1987-94	4	434,733
12	Griffon Gold mine	1993	1998	1998-99	5	62,661
13	Lewis mine s-1984	1981	1984	1984-	3	8,800
14	Mineral Ridge mine (includes Mary-Drinkwater)	1995	1996	1996-99	1	63,471
15	Silver Peak (same areas as Mary & Mineral Ridge)		1990	1990-91	<5	31,000
16	Mule Canyon mine (NGC)	1992	1996	1996-	4	62,135
17	Carlin (Carlin trend) s-1965	1962	1965	1965-	3	2,728,382
18	Rain mine (Carlin trend)	1980	1987	1987-	7	23,447
19	Olinghouse mine	1994	1998	1998-99	4	31,567
20	Oliver Hills mine	1990	1991	1991-92	1	573
21	Paradise Peak mine s-1986	1984	1987	1987-95	3	1,471,103
22	Relief Canyon open pit mine	1983	1984	1984-91	1	164,410
23	Ruby Hill mine (Archimede, Deep East and Achilles)	1994	1996	1996-	2	268,541
24	Sleeper mine s-1985	1984	1986	1986-96	2	1,669,712
25	Western Hog Ranch mine s-1986	1981	1986	1986-95	5	233,243
				Total (group)	25 mines	15,238,114

(continued)

Table C-1 (continued)

"Old Field" (Previously Mined, Previously Known Mineralization or Deposit)

	Name	Discovery Year	Startup Year	Recorded Years of Production	Lead Time	Total Production
1	Flowery (Golden Eagle) opit mine	1978	1988	1988-97	10	23,865
2	Hollister (Ivanhoe) mine s-1990 NGO share	1983	1990	1990-94	7	112,214
3	Big Springs (Sammy Creek)		1987	1987-95	>5	416,021
4	Mt. Hamilton mine	1985	1995	1995-98	10	124,000
5	Toiyabe	1970	1987	1987-91	17	85,080
6	Wright Window mine	1986	1992	1992-93	6	3,500
7	Wind Mountain mine	1978	1989	1989-94	11	292,765
8	Buckskin-National mine	1907	1989	1989-94	>5	539,608
9	Candelaria mine s-1979	1979	1986	1986-	7	127,324
10	Coeur Rochester open pit mine (Rochester Group)	1860	1986	1986-	>5	841,824
11	Denton-Rawhide mine	1983	1990	1990-	7	907,196
12	Florida Canyon mine	1980	1986	1986-	6	1,398,152
13	Getchell mine (and Turquise Ridge mine)	1934	1985	1985-	>5	1,947,716
14	Golden Butte mine	1981	1989	1989-91	8	44,755
15	Goldfield	1983	1989	1989-97	6	28,373
16	Gooseberry ug mine s-1977, 89	1906	1977	1977-92	>5	70,850
17	Jerritt Canyon (Enfield) mine (included Savel Canyon)	1976	1982	1982-	6	5,512,576
18	Keystone (Goodsprings) mine	1982	1990	1990-93	8	1,000
19	Kingston (Sumich) mine	1862	1983	1983-89	>5	68,106
20	Kinsley Mountain mine	1988	1995	1995-	7	138,151
21	Lllipah open pit mine		1986	1986-88	>5	14,116
22	Northumberland mine	1972	1981	1981-93	9	142,779
23	Pinson mine (includes Mag pit)	1971	1980	1980-	9	1,099,413
24	Preble mine	1972	1985	1985-	13	82,489
25	Robinson open pit mine	1980	1986	1986-	6	603,765
26	Rosebud ug mine-project NGC	1906	1997	1997-	>5	338,303
27	Round Mountain (Smoky Valley) mine	1906	1977	1977-	>5	5,848,707
28	Manhattan s-1906, 83	1972	1983	1983-90	11	168,424
29	Santa Fe mine (NGC)	1983	1989	1989-95	6	358,888
30	Star Pointer mine	1981	1987	1987-88	6	50,000
31	Sterling mine s-1983, 86	1973	1986	1986-	13	132,873
32	Thomas W mine	1864	1980	1980-81	>5	600
33	Tuscarora (Dexter) mine	1867	1987	1987-92	>5	34,187
34	Weepah mine	1930	1986	1986-90	>5	58,000
35	Windfall mine	1968	1976	1976-88	8	93,580
				Total "Old Field"	35 mines	21,709,200

APPENDIX D

PRODUCTION AND NUMBERS OF MINE OPENINGS

Table D-1 Production and Number of Mines Classified by Deposit Types and Processing Methods

"New Field" Category

"Related Discovery" Development Type

Deposit Types	No.of mines	Total production	Percent of Total Production
Cavity-fillings	8	9,441,642	17.23
Replacements	7	5,723,762	10.45
Disseminated	26	39,304,734	71.73
"Unknown"	5	326,608	0.60
Total	46	54,796,746	100.00

Processing Methods	No.of mines	Total production	Percent of Total Production
Heap leaching	20	39,769,070	72.58
use refractory treatments	5	n/a	n/a
Combination	11	11,974,958	21.85
Flotation	0	-	0.00
Milling	1	2,322,610	4.24
"Unknown"	14	730,108	1.33
Total	46	54,796,746	100.00

"Greenfield Discovery" Development Type

Deposit Types	No.of mines	Total production	Percent of Total Production
Cavity-fillings	8	2,219,022	14.56
Replacements	2	5,835,536	38.30
Disseminated	10	7,043,837	46.23
"Unknown"	5	139,719	0.92
Total	25	15,238,114	100.00

Processing Methods	No.of mines	Total production	Percent of Total Production
Heap leaching	14	10,303,882	67.62
use refractory treatments	2	n/a	n/a
Combination	3	4,429,661	29.07
Flotation	1	1,916	0.01
Milling	0	-	0.00
"Unknown"	7	502,655	3.30
Total	25	15,238,114	100.00

(continued)

Table D-1 (continued)

"Old Field" Category

Deposit Types	No.of mines	Total production	Percent of Total Production
Cavity-fillings	11	7,903,940	36.41
Replacements	10	11,079,813	51.04
Disseminated	13	2,721,947	12.54
"Unknown"	1	3,500	0.02
Total	35	21,709,200	100.00

Processing Methods	No.of mines	Total production	Percent of Total Production
Heap leaching	22	17,459,363	80.42
use refractory treatments	3	n/a	n/a
Combination	4	3,507,110	16.15
Flotation	1	70,850	0.33
Milling	0	-	-
"Unknown"	8	671,877	3.09
Total	35	21,709,200	100.00

Table D-2 Number of Mine Openings and Average Lead Time Classified by Development Types and 5-Year Period

Development Types	<1970	1970-74	1975-79	1980-84	1985-89	1990-94	1995-2000	Avearge Lead-Time (years)
related discovery		2	1	7	23	7	4	3.33
greenfield discovery	2		1	3	7	4	5	2.87
"old field"			3	6	19	4	3	9.085
"unknown" Development Type	3	1			1			
Total	5	3	5	16	50	15	12	
Avearge 5-year Gold Price (current $/oz.)		79	187	447	391	368	327	

Notes: (1) Average gold price of period 1995-2000 is a 6-year average.

(2) Total number of mine openings and avearge lead-time do not include mines that have incomplete information.

Table D-3 Total Production of New Mine Openings Classified by Development Types and 5-Year Period

Development Types	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99
related discovery	n/a	n/a	510,779	2,644,343	1,973,819	283,615
greenfield discovery	-	79,120	390,000	1,729,045	51,675	488,375
"old field"	-	170,000	1,144,988	1,448,413	553,769	600,454
"unknown" Development Type	85,273	-	-	2,000		
Total	85,273	249,120	2,045,767	5,823,801	2,579,263	1,372,444

Table D-4 Total Production from Both New Mine Openings and Existing Mines Classified by Development Types and 5-Year Period (in ounces)

Development Types	<1970	1970-74	1975-79	1980-84	1985-89	1990-94	1995-1999
related discovery	-	n/a	n/a	520,779	6,349,581	20,867,107	27,059,279
greenfield discovery	n/a	1,671,345	1,231,576	1,308,263	3,802,457	3,156,124	4,068,349
"old field"	-	-	170,000	1,626,590	4,544,503	7,873,724	7,494,383
"unknown" Development Type	n/a	161,453	28,145	-	70	-	-
Total	n/a	1,832,798	1,429,721	3,455,632	14,696,611	31,896,955	38,622,011

Table D-5 Number and Production of Existing Mines Classified by Startup Periods

Number of Existing Mines

	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99
1965-79	6	6	8	4	2	2
1980-84				14	11	5
1985-89					35	21
1990-99						3
Total	6	6	8	18	48	31

Production of Existing Mines

1965-79	1,747,525	1,180,601	1,399,865	3,729,807	10,051,414	10,530,130
1980-84				5,125,865	8,465,114	15,565,252
1985-89					10,793,933	6,384,930
1990-99						4,704,616
Total	3,495,050	2,361,202	2,799,730	12,585,479	39,361,875	47,715,058

Table D-6 New Mine Production from Disseminated Deposit and Other Types of Deposit in Each Period Classified by Development Types and 5-Year Period (in ounces)

Disseminated Deposit

Development Types	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99
related discovery	-	-	420,074	1,403,625	687,905	96,913
greenfield discovery	-	79,120	390,000	306,222	-	393,337
"old field"	-	-	434,333	353,645	112,214	138,151

Orther Types of Deposit

Development Types						
related discovery	-	-	90,705	1,240,718	1,285,914	186,702
greenfield discovery	-	-	-	1,422,823	51,675	95,038
"old field"	-	170,000	710,655	1,094,768	441,555	462,303

APPENDIX E

AN EXAMPLE OF SENSITIVITY ANALYSIS TABLE

Table E An Example of Sensitivity Analysis Table

Name	County	Discovery Year	10 miles	operating	10-20 miles	operating	20-30 miles	operating	30-40 miles	operating	40-50 miles	operating
Fondaway Canyon	Churchill	1988					Relief Canyon	yes-28	Coeur Rochester	yes		
									Thomas W	no		
Bootstrap	Elko	1969	Dee	no	Hollister	no	Mule Canyon	no	Jerritt Canyon	no	Lone Tree	no
			Betze-Post	no	Maggie and	no	Ken Synder	no	Rain	no	Marigold	no
			Post	no	Gold Quarry	no			Fire Creek	no	Buffalo Valley	no
			Blue Star	no	Tuscarora	no					Robertson	no
			Genesis	no							Big spring	no
		10	Carlin	yes-10							Twin Creek	no
											Getchell	no
											Pinson	no
											Copper Canyon	yes
											Surprise	no
Dee	Elko	1982	Bootstrap	yes-3	Carlin	yes	Mule Canyon	no	Rain	no	Lone Tree	no
			Betze-Post	yes	Maggie and	no	Ken Synder	no	Twin Creek	no	Marigold	no
			Post	no	Gold Quarry	no					Buffalo Valley	no
			Blue Star	yes	Tuscarora	no					Getchell	no
			Genesis	no							Pinson	yes
			Hollister	no							Preble	no
											Copper Canyon	yes
											Surprise	no
											Fire Creek	no
											Big Spring	no
Hollister	Elko	1983	Dee	no	Tuscarora	no	Twin creek	no	Getchell	no	Preble	no
					Ken Synder	no	Carlin	yes	Pinson	yes	Surprise	no
					Bootstrap	yes-13			Maggie and	no	Copper Canyon	yes
					Betze-Post	yes			Gold Quarry	no	Fire Creek	yes
					Post	no			Jerritt Canyon	yes	Rain	no
					Genesis	no			Lone Tree	no	Buffalo Valley	no
					Blue Star	yes			Marigold	no	Big Spring	no
									Mule Canyon	no		
Jerritt Canyon	Elko	1973	Big Spring	no	Tuscarora	no			Hollister	no	Maggie and	no
									Dee	no	Gold Quarry	no
									Bootstrap	no	Ken Synder	no
									Betze-Post	no		
									Post	no		
									Blue Star	no		
									Genesis	no		
									Carlin	yes-39		