A

Report

On The

FACTORS AFFECTING LODE MINING IN THE FAIRBANKS DISTRICT, CENTRAL ALASKA

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CONTENTS

Page

Land in General.. 1

Lands Administered by the U. S. Bureau of Land Management.. 1
Lands Administered by the Alaska Division of Lands.. 2
Lands Administered by Private Individuals or Groups.. 3
References.. 5

The Mining Problem.. 6

Vein System, Mineralization, and Structure of a Typical Lode.. 9

History and Development of the Vein Structure and Mineralization.. 12

Mechanization.. 13
Mine Layout and Operation.. 15

Mine Development.. 16
Stoping.. 20
Ventilation.. 21
Water.. 23
Support.. 24
Underground Transportation.. 25
Underground Exploration and Sampling.. 30

Effect of Operation Size.. 31
References.. 32

The Milling Problem.. 34

Introduction.. 34
Milling Problem.. 34
Water.. 37

Engineering Problems.. 38
Water Quality.. 39
Water Regulations.. 39

CONTENTS (Continued)

Page

Structural Considerations........................... 40

Quaternary Unconsolidated Deposits.............. 41
Fairbanks Loess................................. 42

Tailings Disposal................................... 43
Milling Costs....................................... 43
Fifty Ton-per-Day Operation......................... 44
One Hundred Ton-per-Day Operation................... 45

Crushing.. 45
Grinding and Concentration...................... 45
Amalgamation.................................... 46

Five Hundred Ton-per-Day Operation.................. 46

Crushing.. 46
Grinding and Concentrating...................... 47
Amalgamation.................................... 48

References.. 49

Operating Costs... 50

General Statement................................... 50
Labor... 52

Availability of Labor........................... 52
Cost of Labor................................... 54

Wages....................................... 54
Costs of Labor Benefits Required by Law...... 60

Social Security......................... 60
State of Alaska Unemployment Security Tax. 61
Federal Unemployment Tax................ 61
Workmen's Compensation Premiums.......... 62

Other Fringe Benefits....................... 63

Freight and Transportation.......................... 64

Freight Haulage................................. 65

CONTENTS (Continued)

Page

Methods and Routes of Freight Haulage........ 65
Freight Costs.............................. 66

Personnel Transportation........................ 68

Methods and Routes of Personnel Transportation................................ 68
Costs of Personnel Transportation............ 69

Materials and Supplies............................ 70

Petroleum Products.............................. 72
Coal and Propane.................................. 72
Lumber and Building Products.................. 72
Miscellaneous Hardware and Tools.............. 73
Explosives.. 73
Plumbing Supplies................................. 74
Electrical Materials.............................. 74
Foodstuffs.. 74
Track Supplies..................................... 75
Underground Ventilation Supplies.............. 75
Miscellaneous Mill Supplies.................... 75

Power.. 76

Compressed Air..................................... 76
Electricity.. 76
Direct Diesel....................................... 79

Taxes.. 79

Federal Government Taxes......................... 80
State of Alaska Taxes.............................. 82

State of Alaska Corporation Net Income Tax... 82
Motor Fuel Tax.................................. 83
Mining License Tax.............................. 83

Fairbanks-North Star Borough Taxes.............. 84

Borough Property Tax............................ 84
Borough Sales Tax............................... 84

City of Fairbanks Taxes........................... 85

References... 86

CONTENTS (Continued)

Page

Cost Factor Analysis 88

Limitations on Extent of Operations for Direct Cost Comparisons 91
Summary of Direct Costs Comparisons 92
References 99

Capital Expenditures 100

Total Investment Required for a Fifty Ton-per-Day Mine and Mill Plant 100
Total Investment Required for a One Hundred Ton-per-Day Mine and Mill Plant 101
Total Investment Required for a Five Hundred Ton-per-Day Mine and Mill Plant 102
Details of Capital Expenditures 103

Mine and Mill - 50 and 100 Ton-per-Day Operations 104
Mine and Mill - 500 Ton-per-Day Operation.......106
Miscellaneous Items - All Operations............112

Cost of Heating Plant........................112
Cost of Land Acquisition and Surface Exploration....................................113
Amount of Working Capital....................113

Financing 114

Sources of Funds for Initial Capital Investment....115
Sources of Operating Funds.........................116
Summary....................................117
References....................................118

Minimum Values and Tonnages..........................119

Personnel Costs....................................120

Labor....................................120
Staff....................................124

CONTENTS (Continued)

Page

Materials and Supplies....124
Power....124
Amortization of Pre-production Expenses....125
Sales Taxes....125
Amortization of Heating Plant, Land Acquisition, Surface Exploration, and Working Capital....126
Property Taxes....126
Miscellaneous Costs....126
Contingency....127
Smelter Charges and Transportation Costs for Concentrates....127
Mint Charges....128
Required Profit....128
Minimum Values....129
Summary....131
References....132

CONTENTS (Continued)

Page

Appendix I - Direct Costs of Labor Per Shift..........133

Appendix II - Costs of Materials and Supplies.........136

Petroleum Products..............................136
Coal and Propane................................136
Building Products...............................136
Miscellaneous Hardware and Tools................137
Explosives......................................138
Plumbing Supplies...............................138
Electrical Materials............................139
Foodstuffs......................................140
Track Materials.................................141
Ventilation Materials...........................141
Miscellaneous Mill Supplies.....................142

Appendix III - Detailed Descriptions and Costs of Mine and Mill Equipment for 50 Ton-per-Day Lode Gold Operation..............................143

Mine..143
Mill..144

Appendix IV - Detailed Descriptions and Costs of Mine and Mill Equipment for 100 Ton-per-Day Lode Gold Operation..............................145

Mine..145
Mill..146

Appendix V - Detailed Description and Costs of Mine and Mill Equipment for 500 Ton-per-Day Lode Gold Operation..............................147

Mine..147
Mill..148

Appendix VI - Mining Statistics.......................150

Appendix VII - Production and Development Tonnages...151

Appendix VIII - Labor Requirements....................152

Appendix IX - Staff Requirements......................153

Appendix X - Costs of Materials and Supplies by Operational Phase.................................154

ILLUSTRATIONS

Figure		Page
1.	Administration of Lands in the Fairbanks District, Central Alaska	(in pocket)
2.	Idealized Section of Typical Vein	11
3.	Timbered Cut-and-Fill Stoping System Using Slushers and Chutes (Mining Below Main Haulage Level)	(in pocket)
4.	Timbered Cut-and-Fill Stoping System Using Slushers and Chutes (Mining Above Main Haulage Level)	(in pocket)
5.	Detail of Slusher Drift and Ore Chute	18
6.	Detail of Waste Chute	19
7.	Detail of Skip Pocket	26
8.	Suggested Blasting Pattern for Stope (Mining Below Main Haulage Level)	27
9.	Fifty Ton-per-Day Mill Flowsheet	(in pocket)
10.	One Hundred Ton-per-Day Mill Flowsheet	(in pocket)
11.	Five Hundred Ton-per-Day Mill Flowsheet	(in pocket)
12.	Plan View of Pre-production Development, 50 and 100 TPD Operations	(in pocket)
13.	Elevation View of Pre-production Development, 50 and 100 TPD Operations	(in pocket)

TABLES

Table Page

1. Gold Quartz Mills in the Fairbanks District, Alaska, in 1931 35

2. Summary and Comparison of Employment and Earnings of the Mining (Placer and Coal) and Contract Construction Industries in Alaska 55

3. Summary and Comparison of Earnings of Workers in the Mining (Placer and Coal) and Contract Construction Industries in Alaska in 1964 56

4. Expected Wage Rates for Labor in Underground Lode Operations, Fairbanks District, Alaska 58

5. Expected Salaries for Management and Professional Services in Underground Lode Operations, Fairbanks District 59

6. Approximate Freight Rates for Mining Machinery from Seattle, Washington to Fairbanks, Alaska 67

7. Carriers and Fares for Personnel Transportation between Seattle, Washington, or Anchorage and Fairbanks, Alaska 70

8. Comparison of the Cost of Labor for Underground Metal Mining in Fairbanks, Alaska, and Montana 90

9. Comparison of Actual Mine Development Costs in Idaho and Estimated Costs for Fairbanks District, Alaska 94

10. Comparison of Estimated Direct Costs of Development Headings in Montana and Fairbanks District, Alaska 96

11. Comparison of Estimated Direct Costs of Stoping in Montana and Fairbanks District, Alaska 98

12. Summary of Estimated Costs for Pre-production Development and Mine Plant for 50 and 100 Ton-per-Day Lode Mining Operations, Fairbanks District, Alaska 107

TABLES (Continued)

Table Page

13. Summary of Estimated Costs for Erected 50 Ton-per-Day Gold Mill, Fairbanks District, Alaska..108

14. Summary of Estimated Costs for Erected 100 Ton-per-Day Gold Mill, Fairbanks District, Alaska..109

15. Summary of Estimated Costs for Pre-production Development and Mine Plant for 500 Ton-per-Day Lode Mining Operation, Fairbanks District, Alaska..110

16. Summary of Estimated Costs for Erected 500 Ton-per-Day Gold Mill, Fairbanks District, Alaska..111

17. Summary of Costs of Operation for the Mine......121

18. Summary of Costs of Operation on Mill...........122

19. Summary of Costs of Operation for Entire Plant..123

20. Summary of Calculations for Minimum Value of Ore...130

LAND IN GENERAL

Surface and mineral rights in the Fairbanks district are administered by one of the following, depending upon the disposition of a particular parcel of land:

(1) Bureau of Land Management (United States Department of the Interior)

(2) Division of Lands (State of Alaska Department of Natural Resources)

(3) Private individuals

The distribution of the jurisdiction over mineral land rights in the immediate vicinity of Fairbanks is shown in Figure 1 (in pocket). Although the status of ownership naturally varies with time, this map gives a relative indication of the ownership distribution as of August 1, 1966, and may prove helpful in preliminary land investigations.

Lands Administered by the U. S. Bureau of Land Management

In this district there are two main categories of land that are under the jurisdiction of the Bureau of Land Management:

(1) Those lands known as public domain. These lands are open to location of lodes under the basic Mining Law of 1872 as interpreted in U. S. Code Title 30, Sections 21-54, and the Code of Federal Regulations Title 43, Section 185. These lands are regulated further by Alaska Statute Title 27, Section 10, when making lode locations.

Public Law 167, known as the Multiple Surface Use Act of 1955, limits the use of timber on these locations to that specifically required for mining purposes. It also allows multiple use of the surface resources without restriction to an underground operation.

A lode location may be converted to full title by obtaining a mineral patent to the land upon compliance with the necessary requirements.

Mill sites are also locatable on this land providing it is not mineral in character, and the pertinent regulations are complied with.

As Figure 1 indicates, there is no public domain available in the immediate vicinity of the historical lode mining areas of the Fairbanks district.

(2) Those lands withdrawn from mineral location which are being utilized by some federal agency. These lands are mainly composed of military reservations.

Lands Administered by the Alaska Division of Lands

Under the articles of statehood, the State of Alaska was permitted to select large areas of public domain for conversion to state title. In addition, several state-run institutions and local governments were allowed to select lands which could be sold or leased to supplement their incomes. The Division of Lands acts as administrator for these institutions in regard to land transactions. In the Fairbanks district, the main types of state-administered lands are:

(1) General selection lands

(2) University selection lands

(3) School lands

(4) Borough lands (Fairbanks-North Star Borough)

(5) Mental Health selection lands

(6) Navigable stream lands

Figure 1 indicates state ownership of lands already titled to the State of Alaska as well as those under application as of August 1966.

It is important to note that there are separate regulations governing the location or leasing on mineral lands on state property. These are described in Alaska State Statute Title 38, Chapter 5 and in the regulations of the Division of Lands, Title 11, Division 1, Chapter 6. No less important is the fact that the sale of the surface rights of state land does not confer the mineral rights. That is, mineral patents cannot be obtained upon state property.

Prospecting rights and mill sites are available upon state administered land.

Lands Administered by Private Individuals or Groups

Homesteads can be obtained by individuals from Federal Public Domain which is considered as non-mineral in character. With the exception of leasable minerals, any minerals discovered subsequent to his receipt of title, belong to the homesteader.

Individuals that have purchased or leased state lands do not receive title to any minerals subsequently discovered. The mineral rights remain with the state.

Another category of private land is the patented placer of lode claim. Patented placer claims, of course, seldom provide possibility for lode discoveries, although the exception remains, and they are not lawfully exempt from subsequent lode patent. Patented lode claims are final in their exclusion of subsequent lode mining priviledges to outside parties.

A program of mapping patented and unpatented mining claims in Alaska has been initiated by the Alaska Division of Lands. Several such quadrangles covering the Fairbanks area are now available.

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1. Alaska, State of. Mining Laws Applicable in Alaska. Division of Mines and Minerals, 1965. 20 pp.

2. _____. Mining Rights. Division of Lands Regulations Title 11, Division 1, Chapter 6, 1966. 42 pp.

3. Chastain, M. J. Alaska Lands. Alaska Division of Lands Brochure, 1966. 8 pp.

4. Lawlor, J. Alaska Division of Lands, Fairbanks, Alaska, 1966. Personal communication.

THE MINING PROBLEM

The ultimate purpose of this report is to produce an engineering estimate of the minimum grade of lode gold ore, including both the free-milling gold and that gold associated with metallic sulfides, which can be mined at a profit in the Fairbanks district, central Alaska. This estimate is to be based upon the use of an efficient, systemmatic, and proven method of mining that is adaptable to the ore deposits and geologic structure of a typical situation that might be considered an ideal respresentation of the district.

This section of the report will discuss the problems that might be encountered in lode mining in the district, and it will outline a mining system suitable for overcoming these problems.

The sporadic nature and limited success of past mining in the Fairbanks district as shown by the histories of lode operations (See <u>History and Production</u>) may be attributed primarily to the erratic character of the deposits and the resultant reluctance, or inability, of many operators to make the capital investment needed to attain the most efficient operation. This, in turn, resulted in low output per manshift.

The lack of capital investment prevalent in some of the smaller operations resulted in:

(1) The use of out-dated equipment in poor operating condition.

(2) The lack of planned exploration and development for the purpose of providing estimates of future ore position, tonnage, and value. This did not permit an accurate determination to be made of a cut-off grade for ore being currently mined. For instance, no computations were available for the tolerable dilution that would provide maximum profit from an ore body. Consequently, only high-grade ore veins and pockets were mined. It is conceivable that considerable lower grade material might have been economically mined.

(3) The lack of planned exploration and development for indicating future income, which could affect credit, investment, and guarantees of services at reduced prices.

(4) The lack of planned exploration and development for the purpose of maintaining consistent mill heads, and consequently, flow of cash income.

(5) The driving of permanent haulage and ventilation openings in the vein instead of in the footwall, with the consequent problems of safety and expense in driving and maintenance.

The low output per man-shift, caused by the combined lack of capital investment and efficient modern mechanization, obviously resulted in high mining costs. The high costs of current labor dictate the necessity for high manpower outputs, especially in low and moderate grade ores which prevail in the Fairbanks district.

It is the intention here to hypothetically overcome the above deficiencies in designing a systemmatic mining operation. In order to accomplish this, it is necessary to make several assumptions:

(1) A single idealized ore deposit can be used to represent the majority of the ore deposits that exist in the Fairbanks district.

(2) Sufficient ore has been proven by exploration to justify the capital investment for the suggested mining method and the costs of exploitation of this amount of ore.

(3) Sufficient capital is available for use until production becomes self-sustaining. This does not infer that ore production is to be released from the position of having to account for capital expenditures, but merely that there is a means for purchasing equipment and sustaining development until production is in full swing (See section on Financing).

(4) Labor is available, irrespective of cost, in quantity to operate according to the system as outlined (See section on Operating Costs).

(5) The mining property is wholly owned by the operator, and it is protected with adequate land for future underground or surface expansion. That is, the property rights must be uncontested and always enjoy priviledges of unemcumbered access. (See section on Lands in General).

(6) The mine will be assumed to operate continuously throughout the year. However, a 5 per cent contingency in costs will include an allowance for production losses due to fires, labor strikes, major support failures, delays in receipt of equipment and supplies, or sub-standard quality of general mine workmanship.

(7) The mine will operate with over ten (10) men and, therefore, must conform to the appropriate State of Alaska Mine Safety Regulations as published by the Division of Mines and Minerals.

(8) Ore values are to be limited to free-milling gold and gold associated with pyrite and arsenopyrite.

Proceeding from these basic assumptions, the geologic factors must first be examined in order to arrive at the requirements of a specific mining method.

Vein System, Mineralization, and Structure of a Typical Lode

The bedrock formation of the Fairbanks district is comprised predominantly of pre-Cambrian schist of sedimentary origin called Birch Creek schist. The Birch Creek schist is host to most of the economic gold deposits in the region, although lodes have been found and mined in the intrusive granitic rocks. The major portion of the gold and metallic minerals are in hydrothermal quartz veins, but in some cases mineralization extends into the schist beyond the periphery of the quartz veins.

The design of a hypothetical mine and mill will be based largely upon the characteristics of the ore and the host rock. For this reason, the properties of the veins and the ore that they contain have been averaged from descriptions in the literature to give the following standards for this project: _/ 3, 4, 6, 9, 11, 12, 16, 17, 20, 21.

(1) The ore bearing veins are narrow, seldom measuring more than 8 feet in thickness. An average of 47 vein descriptions in literature gives a width of 2.5 feet. Although in some cases the extent of the vein is ill-defined, a 2.5-foot width will be used as typical.

(2) The veins are generally steeply dipping between 45 and 90 degrees. The average of some 60 descriptions gives a value of 65 degrees, which will be used as typical.

(3) The veins are inconsistently mineralized by gold and other metallic minerals, both as to value and to lateral and longitudinal extent. In some cases the wall rock is mineralized to a variable extent. It will be assumed that this mineralization will not extend more than 12 inches into the footwall.

(4) The gold itself may be free or it may be included in the metallic sulfides. The free gold is usually visible, at least after panning.

(5) The metallic minerals generally represent no more than 2 per cent by weight of the vein material. It will be assumed that they also represent 2 per cent by weight of the first 12 inches of the footwall. Therefore, the metallic minerals will amount to 2 per cent of the entire minimum mining width of 3.5 feet.

(6) Stibnite appears in small massive kidneys measuring up to 9 feet in width and 10 to 20 feet in length in random locations. Due to its sporadic appearance, it will not be considered as ore.

(7) The vein quartz is usually opaque white, but it is often stained red by the oxidation of contained iron minerals, or yellow-green from alteration of stibnite and arsenopyrite.

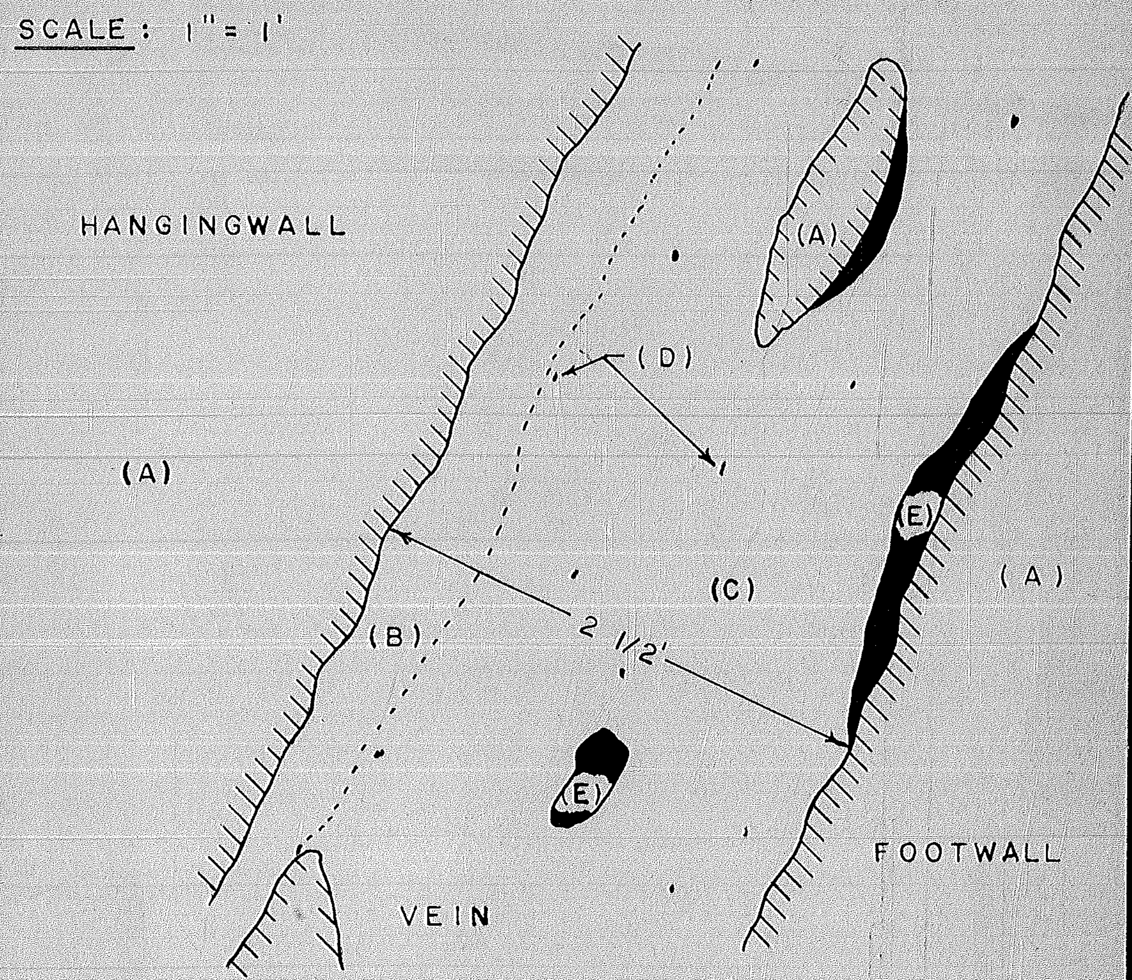
(8) The veins are commonly shattered. From the mining point of view, they are considered heavy ground and are difficult to support.

(9) There is often a 3 to 6 inch width of gouge between the vein and the hanging wall, which gives a distinct parting between the two rock surfaces.

(10) The hanging wall is very heavy and contains considerable water. It should not be disturbed to any extent.

(11) The extent of metallic mineralization at depths beyond 500 feet is unknown, although it is not expected to decrease immediately.

An idealized concept of the standardized vein is shown in Figure 2. This concept will be the basis for the design of the mining system.



LEDGEND

(A) Quartz-Mica Schist (Birch Creek Schist)
(B) Gauge
(C) White Opaque Quartz with Red-Brown or Yellow-Green Stain
(D) Free Gold
(E) Sulphides with Included Gold

FIGURE 2. Idealized Section of Typical Vein

History and Development of the Vein Structure and Mineralization

The major bedrock formation of the Fairbanks district is a pre-Cambrian complex of quartz-mica-schist or quartite schist grouped under the common name of Birch Creek schist. It has been intruded at considerable depth by a granitic magma, as evidenced by coarse crystallization of the apparently slow cooling mass which now breaches the surface in several locations in the area. This intrusive may vary in composition according to location from quartz diorite to porphyritic biotite granite to persilic rock. The quartz diorite contains little metallic mineralization, and its contact effect has been limited to slight alteration of the schists. The porphyritic biotite granite is more abundant and is often mineralized with pyrite.

During the first stage of intrusion there was considerable deposition of white quartz from hydrothermal solutions into faults and joints of the country rock. These quartz veins did not necessarily terminate at the border of the country rock and the intrusive, and they were barren of metallic mineralization during this stage. Subsequent brecciation of the quartz veins was followed by a second deposition of quartz and auriferous solutions. This was the stage of major economic importance. The brecciation is important because it permits the distribution of the gold. Another stage of brecciation followed, with further deposition of quartz along with the metallic sulfides. A final stage of brecciation, with a small amount of quartz deposition, was the latest action and the explanation of why some fissures are not entirely filled.

The general result is that the quartz veins may, or may not, be auriferous, depending upon their susceptibility to deposition after the first stage of brecciation. The veins may, or may not, contain metallic sulfides, depending upon their susceptibility to deposition after the second stage of brecciation. The veins have generally been subjected, with the country rock, to some degree of post-mineral folding, faulting, and brecciation.

The general strike of the main structure in the Pedro Dome area is northeast-southwest, and it has been named the Cleary Anticline. One system of quartz veins in this area has the same general strike as the structure; another system strikes approximately N 70° W. Both systems dip steeply to the south. The veins themselves vary in width from several inches to 15 feet.

The main structure in the Ester Dome area is a fold which strikes nearly north-south. The flanks dip gently to the east and west. The vein system strikes parallel to this structure.

The narrow veins in both areas, up to three feet in thickness, are by far the most productive sources of gold. Some of the wider lodes, comprised of closely spaced veinlets, are seldom minable. The gold appears in small grains or flakes which, in the past, have been liberated by crushing to between -20 and -48 mesh. Gold is sometimes embedded in limonite crystals and, as previously stated, may be included with the metallic sulfides.

The higher grade quartz-gold ores are often stained brownish-red with limonite, or yellowish-green from the oxides of antimony and arsenic. The sulfides usually accompany a fine-grained grayish-white quartz veinlet. These sulfides never seem to comprise more than 2 per cent of the vein, but they do extend into the wall rock.

Mechanization

A general description of the lode mining and milling methods and equipment used in the past in the Fairbanks area has been given in the section on History and Production. In order to emphasize the improvements that can be made in the mining procedures by means of mechanization and modern technology, it will be necessary to discuss past mining methods in more detail.

Comparatively little has been published on the actual mining methods used in the district. The information on this subject has been gathered by personal observation and by personal communication with principals involved in past operations. _/ 2, 5, 7, 10, 19

Considerable material, however, is available on the mining of narrow gold and other veins in general, in other areas. One such publication which discusses the mining and milling of lodes similar to those in the Fairbanks district in the era before World War II is the United States Bureau of Mines Information Circular 6800, "Mining and Milling Practices of Small Gold Mines."

The type of underground method used in the Fairbanks district was cut and fill; more specifically, it was the resuing modification. This method is adequately described in most literature on mining methods. _/ 8, 13, 14. This method obviously required considerable manual labor in breaking the vein from the wall rock, sorting out gangue material, and moving the ore to a chute by shovel or wheelbarrow. In some cases, it was necessary to pick the ore down by hand so as to not disturb the hanging wall by blasting until timber support could be installed. The hanging wall and gouge frequently carried water. In other cases, it was possible to shoot 2 or 3 blast-holes lightly at one time to break the vein from the footwall. In most narrow veins, the minimum mining width required was greater than the width of the vein, and the footwall had to be blasted. This was done subsequent to the removal of a round of ore, and the broken material was used for stope fill. Due to rock swell, the broken footwall might occupy more space than the minimum working room of 30 inches. In this case, the waste rock had to be removed from the mine or taken to some other stope. Additional fill, if needed, was obtained from development headings.

The mining of ore was slow; 1-3 tons per man-shift was average production. Since mill capacities were low, only the richer grades of ore were processed and dilution could not be tolerated.

Generally speaking, the development headings were driven on the vein. For a small operation with limited finances this is a necessity. However, it created support problems of considerable magnitude. Heavy timber (10" x 10") has been inadequate for some of the small drifts. In areas where development was carried out in the country rock, a very minimum of support was required, if any.

None of the mines in the Fairbanks area were comparatively large or deep. The Cleary Hill mine was the largest, extending a maximum of about 1300 feet from the portal, with a depth of about 500 feet from the surface. Ventilation was not a problem. Transportation was not a problem until the underground workings extended 600 or 700 feet from the portal, both laterally and vertically. Slushers and locomotives had not been extensively introduced in the area when production was at its peak. In some cases, there was not capital available for this equipment.

During World War II, the producing gold mines in Alaska were shut down by either rising mining costs or, ultimately, government regulation. Since that time there have been considerable advances in the improvement of mining equipment. However, there has been little opportunity to utilize this technology in the Fairbanks district because the recent operations have all been small, with limited finances. Following are a few items of mechanized equipment and improved technology that could conceivably offset the high cost of labor and help develop a profitable operation, providing the capital investment is available:

(1) Mucking machines for development headings

(2) Slushers for stopes in moving ore and waste fill

(3) Diesel or battery locomotives for transporting ore or waste

(4) Vacuum-type rock drills for areas that present water pumping problems in the winter months

(5) Tungsten carbide bits and carburized drill steel

(6) Ammonium nitrate/fuel oil explosives for use in dry ground

(7) Jack-hammers with air legs

(8) Integral steel with carbide inserts

Mine Layout and Operation

The previous subsection on the veins and structure of the gold lodes in the Fairbanks region indicates that the typical vein which is to be mined hypothetically is to be 30 inches thick, dipping at 65 degrees, is a weak ore, and has a very weak hanging wall. With this simplified description of the ore body in mind, there are several requisites for any proposed mining method:

(1) In order to keep man-power to a minimum, the method must be adaptable to up-to-date mechanization and still maintain the simplicity required by moderate value ore.

(2) It should take full advantage of gravity.

(3) It should be flexible enough to permit the widening of the stopes beyond the minimum width at any time.

(4) It should include some means of temporary support which can be applied quickly, and some means of permanent support for heavy ground conditions over the life of the mine.

(5) It must be capable of handling a moderate amount of water for most of the year, but a considerable amount during the early summer because of seasonal thaw.

(6) It must be capable of continuous operation during the long winter of sub-zero temperatures.

(7) The mining of each ore block should be unaffected by the mining of adjacent blocks, in case barren sections are left unmined.

Mine Development

As the historical lode mining areas have moderate local relief, and most of the known gold lodes in the district extend close to the ground surface, the use of a horizontal adit for the primary haulageway seems to be a logical choice for a typical access. The steep dip of the veins support this approach. A ventilation raise should be driven simultaneously with the extension of the adit to comply with the State of Alaska Mine Safety Regulation (Section 2552.31) that two openings are required to the surface when the workings are 200 feet or more at depth. The main adit should be at the lowest elevation possible, so that maximum use of gravity can be obtained in the stopes. Enough topographic elevation must be left at the portal, however, so that the mill structure may also take advantage of gravity feed.

The adit, ventilation raise, and all other permanent development openings are to be driven in the footwall. Generally, the Birch Creek schist requires a minimum of support when mined away from the proximity of the veins and faults. Although this presents a more costly development initially, it is felt that the overall saving on maintenance, elimination of delays, and increased safety will warrant this procedure.

Above the adit or primary haulageway, the haulage drifts are parallel to the strike of the vein and the primary haulageway, and are placed at intervals of 84 feet along the dip of the vein.

The waste rock from production development headings, even allowing for expansion of blasted rock over rock in-place, will not meet stope fill requirements. However, the deficit fill may be made up by the waste obtained from the ventilation raise or other escapeways which are required by law.

Below the primary haulageway, ventilation openings to the surface are not required (as they are already driven), therefore production development tonnages must match stope fill requirements and the haulageways are spaced closer, at 42-foot intervals. Here, approximately 14,700 cubic feet (minus the volume of the timber) of gob are required to fill each stope after it is mined out. Waste from the haulage drifts spaced at 42-foot intervals (plus ore and waste chute material) will provide adequate fill for each stope. Cold weather problems make it advisable to avoid the use of mill tailings for stope fill.

Figures 3 and 4 (in pocket) show the stope design above and below the adit, respectively, with pertinent dimensions. Figures 5 and 6 show the design of the ore and waste chutes respectively.

An inclined transfer raise is used to connect the lower haulage levels to the primary haulageway. An underground hoist and skip will be used for vertically transporting men and materials.

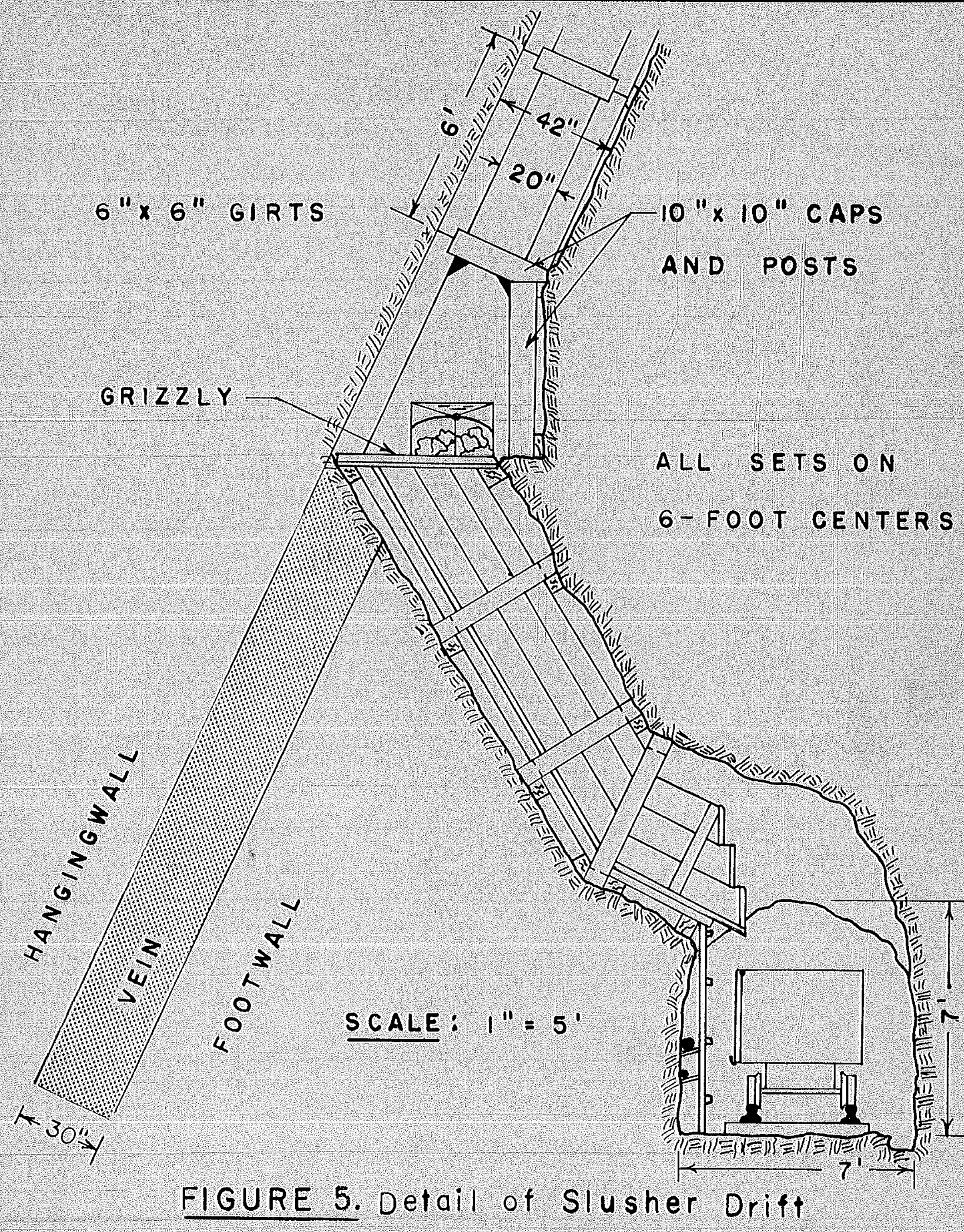


FIGURE 5. Detail of Slusher Drift and Ore Chute

(Mining Below Main Haulage Level)

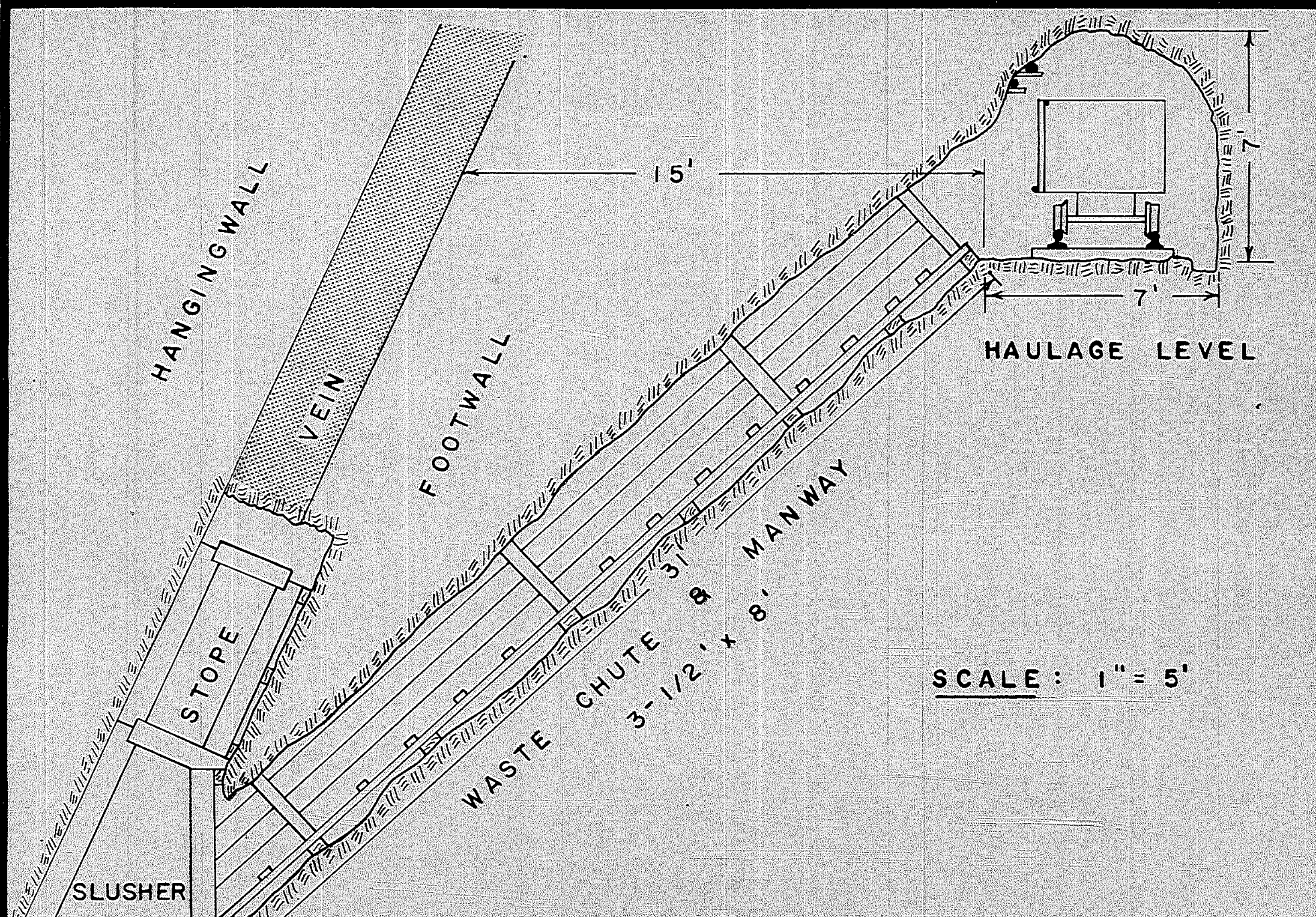


FIGURE 6. Detail of Waste Chute
(Mining Below Main Haulage Level)

It would be practical to mine above the main haulage level first, as it will afford cheaper mining, and lower capital expenditures than mining below this level.

A composite section of the hypothetical mine is not given in this section as its structure would depend largely upon daily tonnage output. However, the individual segments will be outlined here.

Stoping

The ground conditions described above indicate that some form of cut-and-fill mining method should be used. Prior to World War II, the stoping method used was the resuing modification of cut-and-fill mining. However, this method is not adaptable to mechanized mining. The system suggested here is based upon the use of slushers and chutes for the removal of ore and the placing of fill in the stopes. There is no sorting of ore in the stopes. Beneficiation methods are now able to overcome the necessity for high-grading in the stopes; they are described in another section (<u>The Milling Problem</u>). Maximum use is made of gravity.

Minimum stoping width has been selected as 42 inches, with the additional 12 inches of material in excess of the vein coming from the footwall. In some cases this extra 12 inches will be mineralized anyway, as previously noted. This mining width will, of course, be increased if the vein widens. In any case, the minimum working clearance between support timbers will be 20 inches. In the slusher drift floor, the lateral working clearance will be about 40 inches and will allow the use of a 30-inch slusher. The ore is broken from overhead rill stopes and allowed to fall by gravity along the lagging into the slusher drifts below where it is scraped into the ore chutes. Little storage is permitted in the stopes, so the chutes must be drawn regularly. One hundred feet between ore chutes seems appropriate, as greater distances might create scraping problems if the vein curves.

Waste is brought into the stope from a chute at the upper slusher drift. This material is obtained from development workings of the same level. The fill should not lag more than 35 feet behind the face, as the hanging wall produces considerable weight on the timbers for this amount of opening. The timber should be placed as close to the face as possible, and blasting of the rounds should be light to minimize timber damage.

Manways are constructed adjacent to the ore and waste chutes to provide entrance and exit, and completion of the ventilation circuit.

Temporary lagging is placed diagonally across the support timbers, parallel with advance line of the faces, to bulkhead the gob and direct the broken ore to the slusher drift below. This diagonal is approximately 45 degrees from the horizontal; this value approaches the angle of repose of broken rock.

Ventilation

The usual mine ventilating practices should be applicable to any underground operation in the Fairbanks district.

In some northern Canadian mines, it is necessary to heat the air for half the year when the mines are still in the infancy stage and the workings are close to the surface. This is due to icing conditions caused by cold air entering the portal. However, heating of the air will not be considered in this project because of the physical set-up of the hypothetical mine. The Alaska State Mine Safety Regulations (Section 2552.31) require that two escapeways be maintained. A blower fan is installed in the ventilation raise, and the air will be raised to rock temperature by the time it reaches the main working areas. This should minimize icing in the main working areas and at the portal of the main haulageway. It may be advisable to install two sets of doors at the portal to provide an air lock, and prevent cold air from entering the adit.

Compliance with other regulations on ventilation is required by the State. A summary of these requirements that are published under Section 2559 of the Alaska Safety Code is given below:

(1) 100 cfm of free air is required for each employee underground.

(2) An air velocity of 30 linear feet per minute shall be maintained in working places after blasting.

(3) Minimum limitation on oxygen in the air underground is 20% by volume.

(4) Where 25 men or more are employed underground, or where any working is 1000 feet deep vertically or 2000 feet horizontally, from the nearest surface opening, the air circulation must be controlled by a fan. This fan must be installed at the surface, must be reversible, and it must be kept running continuously while men are underground.

(5) All rock chutes must be equipped with some means of watering down the dust.

(6) Diesel engines must be equipped with some means of exhaust conditioning so that the gas temperature does not exceed 180°F.

(7) Ventilating air must be increased by 100 cfm for every brake horsepower of every diesel engine.

(8) Maximum limitations on toxic gases:

a) Carbon monoxide	- 0.01%	(by volume)
b) Carbon dioxide	- 0.5%	"
c) Oxides of nitrogen	- 0.0025%	"
d) Aldehydes	- 0.001%	"

(9) Diesel equipment must not be operating when fan(s) is down.

(10) Diesel engines cannot be operated when flammable gas (methane) exceeds 1¼% by volume.

The usual bulkheads and auxiliary blower fans and vent tubes are required for diverting air currents and for ventilating dead-end headings, respectively. After the stopes are sufficiently opened between slusher drifts, blowers should not be required as the ventilation circuit through them would be complete.

Water

The handling of water is a problem peculiar to northern mining in the winter months and early summer. It will be discussed from three points of view:

(1) The disposal of water from the underground workings.

(2) The maintenance of a water supply for rock drills and the suppression of dust in the rock chutes and stopes.

(3) The elimination of condensed water in the compressed air lines.

For about seven months of the year, water in the rock and soil near the surface of the ground is frozen and offers few problems. It actually works to the advantage of the miner in this frozen state in that he does not have to cope with its disposal, and it permits him to mine ground that would otherwise not be possible or economical from the point of view of support. In other words, the frozen ground essentially becomes self-supporting. This pertains, also, to the perimeter of existing mine openings that are exposed to the cold outside air. In the lower valleys, where deeper gravels and soil exist, perennially frozen ground is encountered, but this is not a problem involving water.

It has been the practice in the past to hold the seasonally-frozen ground as best as possible during the summer, and then mine it in the winter. During the thawing stage in early summer, this ground requires special attention along with the water that is produced from the thawing ground and the surface runoff.

The normal water handling procedures are applied in the mine design. The primary haulageway is sloped to the portal by a 1% grade, and it is supplied with a drainage ditch.

The other haulage levels slope towards the transfer raise which has the usual sump and submersible pump at the bottom.

The pumping of water to the surface for disposal during cold weather can lead to difficulties. One solution to this problem is to construct an underground reservoir, seal its walls and floor chemically or with grout or gunnite, and pump the excess mine water into it. The solids will settle and clear water can be extracted at the top for drilling and dust suppression purposes. For instance, a 7 foot by 7 foot drift, 100 feet long, bulkheaded to 5 feet in height, will hold approximately 26,500 gallons of water.

There are two alternatives to the reservoir procedure. First, underground wells may be drilled to provide a supply of usable mine water. Second, jack-hammers are available on the market that do not require water for drilling. They are equipped with a vacuum-type dust collector which draws the cuttings through the drill steel and machine jacket rather than blowing them out the drillhole. These machines would be applicable in areas, during sub-zero weather, where water would normally freeze in the lines or in the drill or drillhole.

Section 2549 of the Alaska State Mine Safety Regulations covers the requirements for drill dust control.

During the cooling of compressed air as it travels into the mine, considerable water condenses in the lines. In sub-zero weather, condensation is considerable in unprotected lines. The ice that forms will reduce the efficiency of the compressor, and eventually, it will close off the line. To eliminate this problem, the air receivers should be housed in a temperature-controlled structure where they can be drained regularly, and the main header should be run through utilidors or some means of insulation for some distrance into the mine. Regular drainage cocks should be installed at low points in the inner-mine air system. Tanner gas, or some alcoholic fluid, may be periodically added to the air in the receiver to further prevent moisture freezing.

Support

The State regulations (Section 2555) require that support be maintained as conditions warrant for the safety of the miners.

The permanent development headings have been designed in the footwall. Since the ore and the hanging wall are both weak, this appears to be the safest and most economical approach in the long run. It is assumed that 40% of the haulage drifts will require timber support. The timber used has been standardized at 8 in. x 8 in. in cross-section. The drifts measure 7 ft. x 7 ft. Rock bolts are not considered as applicable because of the poor anchoring characteristics of the schist. The waste chutes will not be timbered; the ore chutes will be timbered entirely. The inclined raise will be timbered and bearing sets utilized at 50-foot intervals.

Since the hanging wall is very heavy, it will require permanent support in addition to the temporary timber sets. Waste fill is used for this purpose as outlined previously, and it is obtained from development headings driven simultaneously with the stope excavation. The gob is trammed to the waste chute on the haulage level and dumped by gravity into the slusher drift, where it is moved into the stope by the slusher.

All timber posts in the stopes are 10 in. x 10 in.; the girts are 6 in. x 6 in.; the caps are 10 in. x 10 in. The set dimensions are given in Figure 5.

Lagging will normally be required with all timber sets installed in the development headings. It will be used in the stopes for confining the waste fill and for guiding the blasted ore to the slusher drift below. In most cases, the lagging should be reusable as the fill line is advanced.

The pillars between the haulage drifts and the stopes will be maintained at a minimum of 15 feet. This will minimize chute development and still provide safety until the stope is filled. The pillar around the inclined raise should be maintained at a dimension of 50 feet on all sides.

Skip pockets will be timbered as shown in Figure 7.

Underground Transportation

This section will briefly outline seven phases of transportation involving men and materials underground:

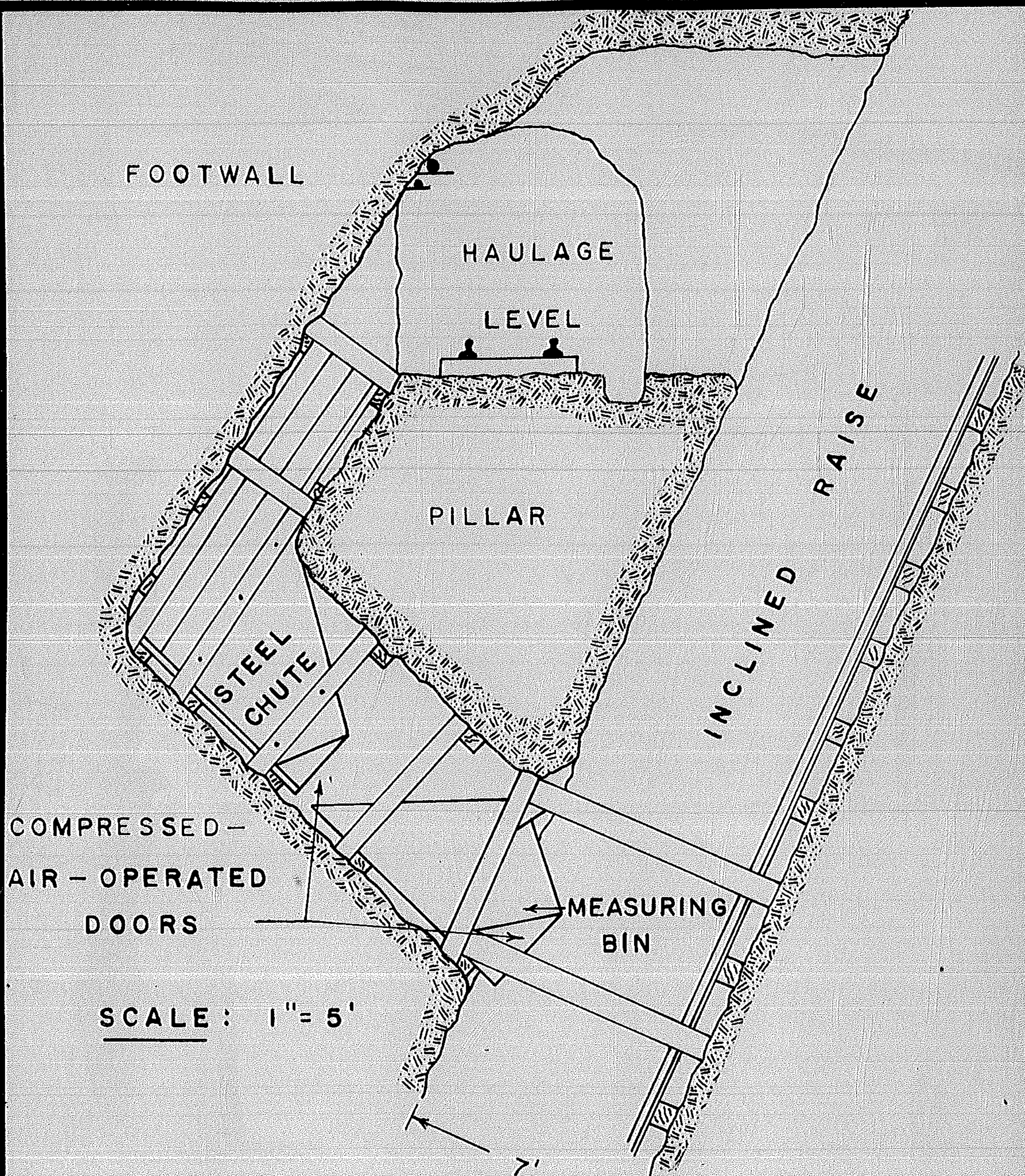
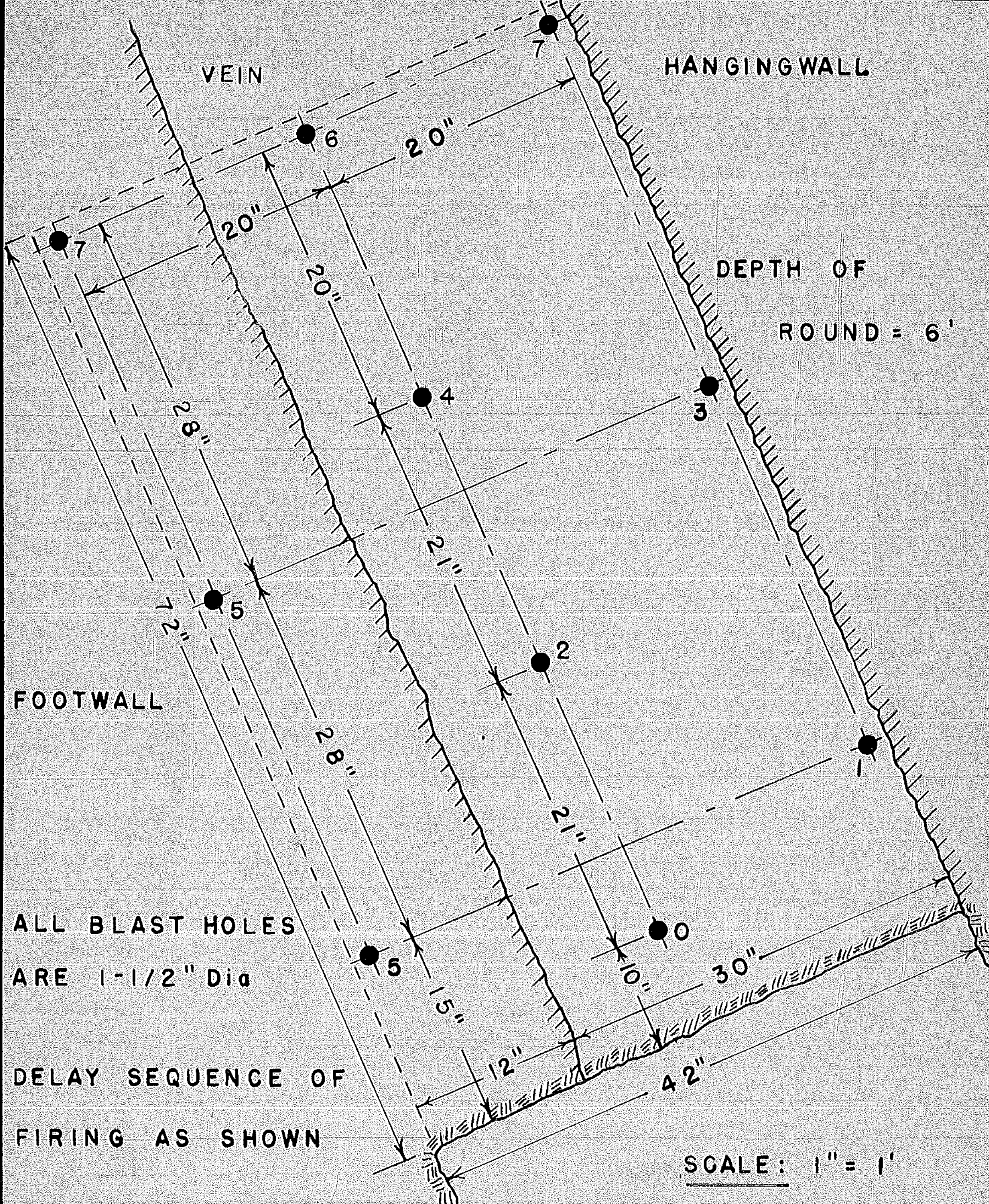


FIGURE 7. Detail of Skip Pocket
(Mining Below Main Haulage Level)



(Mining Below Main Haulage Level)

FIGURE 8. Suggested Blasting Pattern for Stope

(1) Ore haulage from the stope to the ore chute at the end of the slusher drift by slushers.

The slusher is to be maintained as a permanent installation for the life of the stope. A compressed air tugger motor would be appropriate as an air line must be brought into the stope anyway for the drills. The ore is scraped into a grizzly at the mouth of the chute, allowing -12 in. material to pass through. Larger material is broken on the grizzly rails.

(2) Ore haulage from the ore chute, along the haulage level to the skip pocket at the transfer raise or main ore chute by locomotive and side-dump cars.

An air or battery locomotive pulling side-dump cars is applicable to this phase. The same unit will be used to bring waste rock from development headings on the same level to the waste chutes.

(3) Ore haulage from the haulage level to the primary haulageway by skip in an inclined raise (for stopes below primary haulageway) or main ore chute (for stopes above main haulageway).

Specific regulations on skips and cages are given in Section 2550 of the State code. These regulations govern the design of equipment, standardization of signals, periodic inspections, skip operation, and personnel-carrying restrictions.

It is assumed that an operation of 50 tons per day or less would use the skip for materials handling only. Above this tonnage, the mine would develop large and deep enough to warrant use of the hoisting system for personnel also.

(4) Ore haulage from the ore pocket on the primary haulageway to the mill by diesel locomotive and side-dump cars.

The main ore pocket at the top of the

inclined raise should be large enough to accommodate a backlog of ore. The specific volume would be dependent upon the size of the ore train on this level, and ultimately upon the daily output of the mine. For instance, it may have the capacity of one full train load of 8 or 10 cars so that the ore can be stored while the train is making its run to the mill. Under-design of its capacity would serve as a bottleneck to production from the lower levels.

A heavier locomotive and larger capacity cars than those used on the haulage levels would be required, along with corresponding heavier track and accessories.

(5) Waste haulage from development headings to the waste chutes at the stopes by locomotive and side-dump cars.

This phase has been outlined in phase (2) above.

(6) Waste haulage from chute to the stopes by slusher.

The same slusher that is used for moving ore into the ore chute would be utilized for this work.

(7) Personnel Transportation:

As long as the mine remains relatively small and shallow, with only two or three levels, personnel can travel to and from working places by means of the manways along the inclined raise or through the stopes. Eventually, as the mine grows in size, below the main haulageway, a man-skip should be provided to transport personnel to lower levels. Intra-level transportation, of course, can always be maintained by man-train.

Underground Exploration and Sampling

In order to maintain a systematic mining operation, it is necessary to continually develop new blocks of ore. This requires a systematic underground exploration and sampling program. As this work represents the life-line of the mine's productivity, it is essential that a portion of the operating budget be set aside for its existence. The exact amount of the budget that is allotted will be dependent upon the daily mine production, which, consequently determines how soon new blocks of ore will be required.

For instance, a 50 or 100 ton-per-day operation would only require the part time efforts of an engineer or geologist and a helper to be assigned to sampling and assaying, and a full time exploration crew. On the other hand, a 500 ton-per-day operation would require a full time exploration crew, assayer, and sampler.

There are two aspects of underground sampling for the hypothetical situation at hand. First, there is the systematic sampling of stopes by personnel responsible for sampling. These samples would be taken periodically and assayed for gold and silver content. Channel samples would be appropriate in this case. The resulting values would be the major guide-line as to the ore value of general areas, such as a complete block of a stope (84 ft. x 100 ft.) or major portion thereof. However, in small localized zones or pockets, encompassing just a few tons, it should be the prerogative of the shift boss, on the basis of panning and his experience, to determine if mining is warranted. In both cases, values are compared to a pre-determined cut-off grade, which is a mine-wide standard, to arrive at the appropriate decision.

Because of the irregularity of the veins in thickness and value, underground exploration drilling can accomplish little more than to determine the existence and location of new veins and the presence of gold in them. The value of drill cores and sludge should not be accepted as reliable to estimate present value of an ore block. When a block of ore has been developed and evaluated by perimeter sampling, it is necessary, but even then speculative, to claim the entire volume as proven ore. This, indeed, is one of the most serious problems involved in the exploitation of this type of deposit. Utmost caution cannot be over-stressed.

Exploration and evaluation techniques should, then, follow this sequence:

(1) Core drilling with diamind drills underground to locate the extension of old veins, or the presence of new gold-bearing veins.

(2) Follow-up of exploration drifts to determine the average grade and widths of the newly located vein.

(3) Final development, sampling, and evaluation of the ore blocks.

Effect of Operation Size

The minimum value of lode gold at which the foregoing hypothetical operation can be maintained at a profit will be estimated in a later section (Minimum Values and Tonnages). This estimate will be made for each of three selected daily productions: 50, 100, and 500 tons-per-day.

Obviously, the 50 ton-per-day operation will differ from the 500 ton-per-day operation in many respects, such as the amount, size and specific type of equipment, extent of development and exploration, work procedures, number of working shifts per day, and the reserves of the ore body. The section above has circumvented these variables intentionally, and has merely attempted to describe a limitless method of mining adaptable to all three cases, without regard to quantities.

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THE MILLING PROBLEM

Introduction

In the past, inadequate planning and testing of ores prior to mill construction has been the rule for mill construction. The ores mined were generally high-grade, and tailing losses often amounted to 15%. _/ 5. Mills were often constructed prior to development of sufficient ore reserves, which generally resulted in development having to pay for itself. Capacity of gold mills in the Fairbanks district ranged from 2 to 50 tons per 24 hours. Table 1 illustrates some typical mills in the district in 1931.

Milling Problem

A short discussion of major factors affecting the milling of gold ore in the Fairbanks district is given below. This discussion is not intended to be a complete review of all milling practices in the past, but a generalized statement on the operations.

Generally, ore was brought to the mill in hand-trammed cars and dumped onto an inclined grizzly with the underflow

TABLE 1. Gold Quartz Mills in the Fairbanks District, Alaska, in 1931. _/ 5

NAME OF MILL	COARSE CRUSHING	FINE GRINDING	GOLD-SAVING EQUIPMENT	POWER PLANT	CAPACITY
		Ester Dome Region			
Ready Bullion	Jawcrusher	2 Nissen stamps	12 x 4 ft. plate	Wood, steam 30 HP	15 tons 10-hr. shift
Mohawk	Jawcrusher	8 ft. Lane Chile type mill 20 mesh	"	Semi-diesel 15 HP	20 - 30 tons 24 hours
St. Paul	Jawcrusher	"	"	Wood, steam 20 HP	10 tons 10-hr. shift
Elmes	Jawcrusher	5 stamps	"	Wood, steam 30 HP	15 - 20 tons 24 hours
		Pedro Dome Region			
Soo	Jawcrusher	2 stamps 20 mesh	8 x 3 ft. plate	Gasoline 10 HP	5 - 10 tons 10-hr. shift
Cleary Hill	7 x 9 in. Blake jawcrusher	5 stamps 20 mesh	12 x 4 ft. plate	Diesel 100 HP	15 - 20 tons 24-hr. shift
Crites and Feldman (old)	"	"	"	Coal, steam 30 HP	"
Crites and Feldman (new)	"	Gibson rod mill, 30 mesh	12 x 3 ft. plate	Gasoline 15 HP	5 - 10 tons 20-hr. shift
Newsboy	7 x 9 in. Dodge jawcrusher	5 stamps 20 mesh	12 x 4 ft. plate	Wood, steam 40 HP	15 - 20 tons 24 hours
Gibson	"	"	"	Wood, steam 30 HP	"
Chatham (dismantled)	7 x 9 in. Blake jawcrusher	10 stamps	-	-	-
Wyoming	Jawcrusher	Herman pebble mill	8 x 2 ft. plate	Gasoline 10 HP	5 - 10 tons 24 hours
Tolovana	6 x 6 inch Jawcrusher	2 Nissen stamps	10 x 4 ft. plate	Wood, steam 40 HP	15 tons 24 hours

passing into a small-capacity ore bin. The oversize fell onto a platform where it had to be manually shovelled into a small jawcrusher for further reduction. A few mills incorporated secondary breakers, especially of the roll crusher type. From the crushers ore was fed to the stamps either by shovelling or by automatic feeders. Stamps were used for fine grinding, the fineness of the grind often being regulated by the mesh screen "on hand" rather than one expressing the economic liberation point of the gold. Stamps overflowed to amalgam plates where the gold was saved and the plate overflow was sometimes sent to tailings. Other mills used gravity or flotation for further recovery of gold values. Mill recoveries were 85% at best and averaged 75% or less. _/ 5.

Capabilities and power supply for some of these mills may be observed from Table 1. Water was obtained in a variety of ways. A few used mine water; however, most used a combination of shallow wells and creek water. Several mills shut down during the winter months due to inadequate development of wells for water.

Major problems associated with the mills in the Fairbanks district may be categorized as:

(1) Excessive manpower per ton per day

(2) Limitations of grinding method

(3) Limitations of the concentrating method

Excessive manpower resulted from manually handling the ore at the grizzly, hand feeding the jawcrusher, dressing belts and repairing "cracker-box" type structures and equipment. This may be overcome by proper layout and the incorporation of materials handling facilities necessary for the efficient transport of ore. Manpower costs per ton can be further reduced by installing central control panels and automatic features for regulating mill throughput. These devices and equipment will pay for themselves many times over during the life of the mill.

Stamp mills have been out of date for years, and a discussion of their demerits is not necessary. The major limitation is their inefficiency in terms of the amount of grind per-dollar-of-power and the fineness and quality of the grind obtained. This may be overcome by using ball or rod mills in closed circuit with a spiral classifier.

The concentrating method used is one which has in the past supplied millions of dollars in gold to the national coffers. However, recovery was often low (less than 75%). Efficient concentration methods for mill design purposes can only be achieved by adequate testing prior to mill design. If 75% is recoverable by direct amalgamation, means must be devised to recover the additional 25%, or there will be considerable losses in profit. On moderate to large tonnage mills (excess of 100 tons per day) the investment of gravity, flotation, or even cyanidation equipment will generally be warranted to recover such losses.

Water

In the past many small mills shut down during winter months due to lack of water. In most of these cases, however, local streams were being used for water supply. These would freeze during the winter leaving mills out of water. Several mines developed water in shear zones in amounts sufficient to operate small mills, but others were almost dry. A recent report of the Institute of Social, Economic and Government Research of the University of Alaska summarizes the known information concerning water in the Fairbanks district. _/ 6

This report indicates that little is known of any wells that might have been drilled on the floodplains of the major streams - the Chena, Salcha, and Chatanika Rivers and Goldstream Creek. Past experience in placer mining, however, suggests that much of the shallower parts of the stream valley are probably frozen to bedrock. Shallow ground water may, of course, be obtained near the streams. Yields in excess of 100 gallons per minute are speculated by Cederstrom as being possible from buried alluvium of the upland valleys along Farmers Loop Road and the Steele Creek Road. _/ 2

Almost all the wells in the uplands obtain their water from bedrock. Yields from bedrock sources range from almost zero to 57 gallons per minute. _/ 2 The University of Alaska obtained its water from bedrock for years. These wells were constructed by drilling holes and drifting collector openings laterally from sumps.

Water from the Tanana floodplain is plentiful:

> "Practically every well that has been drilled on the floodplain near Fairbanks has a high yield. No failures due to lack of a suitable water bearing formation are known. It appears that exceedingly high yield can be obtained anywhere, even from poorly constructed wells that, ordinarily, are less than 250 feet deep. The depth to static, or non-pumping, water level ordinarily is about 10 or 12 feet below the land surface, and it is not known to be more than 16 feet below the land surface anywhere." _/ 2

Yields from properly developed 6-inch wells exceed 150 gallons per minute. Large industrial wells have delivered 2800 gallons per minute with 22 feet drawdown. The Fairbanks Municipal Utilities System owns an 18-inch diameter well which has yielded 3400 gallons per minute. _/ 6

It is evident that testing for water at the proposed site is a necessity. Six-inch diameter holes in hard rock can be contracted for $10 per foot using modern rotary drills.

Engineering Problems

The University of Alaska, the City of Fairbanks, the military, the Public Health Service, and the State Department of Health and Welfare have all had experience with water distribution in the cold regions of Alaska.

The City of Fairbanks buries its water mains about six feet deep. Velocity of water in the main lines is three feet per second, and in distribution lines it is 0.2 feet per second. _/ 6 Constant circulation is maintained by using closed-loop circuits.

Water Quality

The quality of water may best be described by quoting Cederstrom: _/ 2

> "The water may be characterized as an alkaline, moderately hard to hard calcium bicarbonate water which ordinarily contains appreciable or objectionable quantities of iron. Objectionable quantities of manganese also were generally associated with the high iron content in the samples analyzed. Sulphate was high in a very few samples. Chloride and fluoride were low. A few samples had a relatively high content of nitrate which suggested possible pollution.
>
> The hardness of the water from wells is more than 100 ppm and more commonly ranges from 100 to 300 ppm. Only a little of the hardness is of the non-carbonate (permanent) type, but exceptions may occur; water from well 219, in Fairbanks, had a total hardness of 281 of which 32 ppm was of the non-carbonate type."

Water Regulations

The Alaska Water Use Act of 1966 provides a system of appropriation and use of water. Forms and applications for appropriation of water may be obtained at offices of the Division of Lands located at:

Anchorage:	344 Sixth Avenue Anchorage, Alaska 99501
Fairbanks:	Room 107, State Court and Office Building Fairbanks, Alaska 99701
Juneau:	Goldstein Building, Pouch M Juneau, Alaska 99801

Completed forms and applications must be sent to:

Division of Lands
Branch of Water Resources
344 Sixth Avenue
Anchorage, Alaska 99501

Structural Considerations

Foundation requirements and earthquakes are abnormal problems and must be considered prior to construction of buildings in the area. Wind and snow loads are considered as normal engineering problems.

Foundation conditions must be confirmed by drilling and trenching in the Fairbanks district because considerable difficulties may otherwise result from permafrost and ground ice. Conditions existing in the district are well covered in available reports and maps of the United States Geological Survey. Hardrock units existing in the district in the Cleary Summit area are listed as follows: _/ 1

Pelitic Schists and Quartzites

micaceous quartzites
quartz-mica schists
mica schists (muscovite and/or biotite)
garnet-mica schists (w/rare staurolite
 or andalusite)

Gneisses

garnet-mica gneisses
epodite bearing biotite gneisses

Amphibolites and Lime Silicate Rocks

tremolite - carbonate - schists
chlorite - carbonate - quartz schists
clinozoisite - carbonate - quartz schists
clinozoisite - actinolite - phlozopite -
 oligoclase schists
amphibolites
 oligoclase - epidote amphibolites
 garnet - biotite amphibolites

Marbles

chlorite bearing tremolite marbles
clinozoisite marbles
phlogopite marbles
siliceous marbles

The Birch Creek schist underlies most of the district and generally provides a good foundation. It is well drained. The micaceous varieties break down rapidly by weathering and may be subject to sliding if foliation planes dip in the same direction as the slope.

Metamorphosed mafic and ultramafic rocks occur intermittently between the Chena and Salcha Rivers. Mertie _/ 7 says that these are in part ophicalcite (serpentine marble) and are in places extensively serpentinized. If so, special attention should be given them prior to road or mill construction.

The granites, quartz-diorites, and quartz monzonites within the district should all provide strong foundations free from frost problems.

Basalt occurs on the lower slopes and hills in the vicinity of Fort Wainwright. _/ 6 There are also outcrops on Kokomo Creek and Fourth of July Hill north of Fairbanks. This rock should be good foundation material.

Quaternary Unconsolidated Deposits

There are twenty-one units of unconsolidated surficial material within the district. Many of these are not suitable for foundations or roads. The more important units are described below. Reference to United States Geological Survey reports is advised prior to construction.

Muck (Perennially frozen silt, undifferentiated, Qsu)

Consists of retransported loess which has moved down to lower slopes and valley bottoms, and is frozen everywhere. Permafrost ranging from 3 to 200 feet in thickness occurs in the valley bottoms. It is an ideal material for formation of ground ice and is very frost susceptible. It provides very poor foundations.

Fairbanks Loess (Qf)

This is silt blown from the bars of glacier-fed streams during the Ice Age. It occurs on low hilltops and higher slopes. The thickness ranges from a thin veneer near the tops of hills to more than 200 feet near the lower slopes. Permafrost is absent except, possibly, on poorly drained north-facing slopes. Frost susceptibility is low, although it will increase if an adequate supply of water is available. In an undisturbed condition the loess is homogeneous, massive, well sorted, and locally cemented. In the undisturbed state it has good bearing strength.

Reworked creek gravel and placer tailings (Qg provide excellent construction material and foundations.

The gold-bearing areas of the Fairbanks district are generally associated with the Birch Creek schist. Mill foundations would generally be located on this unit.

Building design should incorporate earthquake features. The district lies on the northern edge of a curving seismically-active belt that parallels the Alaska and Coast Ranges and the Aleutian Islands. _/ 6 A shock of magnitude 6 or 7 occurs about every decade somewhere in interior Alaska. The most severe quake felt in Fairbanks was on January 21, 1929, and it was caused by a quake near the head of the Tatlanika River, 60 miles away. _/ 4 The closest epicenter positively located was about 30 miles southeast of Fairbanks (July 22, 1937). _/ 4

Design loads for wind of 15 pounds per square foot are used in the district. Forty pounds per square foot are used for snow load. Due to the extremes in temperature, buildings should be designed with 4 to 6 inches of glass-wool or equivalent insulation in walls and 6 to 8 inches in the ceilings. Weather records may be obtained from the United States Department of Commerce. _/ 8

Tailings Disposal

Tailings disposal for large capacity mills must be designed to adequately handle pulps in weather exceeding 50° below zero. Mills built on hillsides should not depend upon a gravity head for transportation of tailings to the disposal area. Practice at Usibelli Coal Mine has shown that large positive pump heads will prevent freezing. _/ 3 A method used at this mine is to pump up an elevated pipeline, adding sections of pipe as the waste piles are built up. This problem requires special consideration depending upon the mill site chosen, and the requirements for reclaiming additional water. Water in the static pond will freeze to a depth of approximately 6 feet if the ground underneath the pond is not frozen.

Requirements for stream pollution are becoming more stringent in Alaska. At the present time, however, it is permissible to allow sands to be carried away by streams and rivers.

Milling Costs

In order to develop cost data for gold mills in the district, a typical set of conditions was assumed, concerning ore composition, approximate ore tenor, tonnage, etc. Mills were then designed to meet these conditions and costs developed are considered typical, but no guarantee is implied that these mills are best for the ores of the district, or that they are the lowest cost possible.

A review of the metallurgy of the theoretical ore is deemed appropriate at this time. The ore is gold quartz, containing some Birch Creek schist and 2% sulphides by weight. Eighty-five per cent of the gold is assumed recoverable by amalgamation, 10% by tables or flotation, and 5% goes to tails.

Three mills have been designed and cost data computed therefrom. A discussion of the flowsheets follows below; capital and start-up costs are listed in the section on

Capital Investment, and costs of operation are summarized in the section on Minimum Values and Tonnages. As indicated in the section on the Mining Problem, the above items will be discussed for each of a 50, 100, and 500 ton-per-day operation.

Fifty Ton-Per-Day Mill Operation

Operation and design of the 50 ton-per-day mill closely parallels that of the 100 ton-per-day concentrator, with the exceptions noted below.

The 50 ton-per-day mill was designed to handle theoretical capacity of the mine, 65 ton-per-day, with one shift in the crushing plant and three shifts grinding and concentration. Coarse and fine bins are of 50 ton capacity each. The crushing circuit is exactly the same as that of the 100 ton-per-day operation except that the operation is for one shift. Major differences in the grinding and concentration stage are in the:

(1) Ball mill size for 50 TPD - 4' x 8'

(2) Classifier size for 50 TPD - 24" x 16'

(3) Motor horsepowers for 50 TPD - less than for 100 TPD

Concentrate handling facilities were kept to a minimum due to the relatively small tonnage of the concentrates. Future mill refinement should consider a small capacity thickener and disc filter for water removal.

The flowsheet for the above operation is shown on Figure 9 (in pocket).

One Hundred Ton-Per-Day Mill Operation

Crushing

The crushing circuit has been designed to operate two shifts per day for a total of 100 tons for 14 hours operation. Ore is brought to this section by 90 cubic-foot Granby type ore cars which are dumped by a dumping block into a 100-ton capacity ore bin through an 8-inch grizzly. Oversized will be broken manually. This bin is of timber and steel constuction and placed to take advantage of a hillside slope. A bin of this capacity will assist continuous mine operation in event of crusher failure. A 30 in. x 10 ft. apron feeder with variable speed drive is used to deliver ore to a 1-inch grizzly. Height of ore is regulated by a rack and pinion gate. The grizzly has been provided to allow fines to bypass the crusher and for removal of clay material which may cause sticking. A 10 in. x 16 in. single toggle jawcrusher with a 1½-inch open set is used to crush oversize from the grizzly. Undersize ore from the grizzly and crusher are combined onto a 18 in. x 37 ft. conveyor which transports material to a 100-ton circular fine ore bin. This bin is provided to insure a one-day mill run should the crushing circuit have equipment failure.

Grinding and Concentration

The grinding circuit is a simple concentration system designed to provide maximum recovery at minimum equipment cost. It is run three shifts per day and outputs 100 tons. Ore is delivered to a 5 ft. x 8 ft. ball mill from the fine ore bin by a 12 in. x 20 ft. belt feeder, equipped with variable speed drive. Height of ore on the belt is regulated by a rack and pinion gate. The ball mill operates in closed circuit with a 12 in. x 18 in. duplex jig for immediate removal of coarse gold, a set of 4 ft. x 12 ft. amalgam plates, and a 36 in. x 16 ft. spiral classifier. The classifier overflows at 65 mesh and pulp is laundered to a size 6S Wilfley table for concentration of heavy sulphides. Table concentrates are laundered to 50-gallon drums which are left standing open until shipment. Middlings are laundered to a 10 cubic-foot fabricated steel sump from which they are pumped by a 2 in. x 2 in. sand pump to the ball mill. Tailings are laundered from the table to a 40 cubic-foot sump from which they are pumped by a 2 in. x 2 in. sand pump to the tailings disposal area.

Amalgamation

Jig concentrates are laundered to a 42 in. x 48 in. amalgamating unit. Gold amalgam is removed and retorted. Tailings from this unit are combined with the table concentrates for shipment to a smelter.

The flowsheet for the above operations is shown in Figure 10 (in pocket).

Five Hundred Ton-Per-Day Mill Operation

Crushing

Ore is brought to a 12-inch grizzly by ore car. Grizzly spacing is governed by the mining method and crusher size. It is anticipated that few rocks will be larger than this size. These will be broken manually. The grizzly undersize falls into a 500-ton capacity coarse ore bin. This size bin has been provided to insure continuous mine operation during periods of down time in the crushing plant.

The crushing plant is designed to process 500 tons per day in two shifts, the third shift being reserved for maintenance. Ore is withdrawn from the coarse ore bin by a 30 in. x 14 ft. apron feeder which is equipped with variable-speed drive. Height of ore is regulated by a rack and pinion gate installed on the ore bin. The feeder delivers ore to a 36-inch, pulsating-magnet grizzly (1 in. spacing), installed to by-pass fines from the primary crusher. This grizzly also removes a large percentage of clay or gouge which would otherwise plug the primary crusher. Oversize is delivered to a 15 in. x 24 in. single toggle jawcrusher with a 4-inch open set. Undersize from the grizzly and crusher are combined on an 18 in. x 37 ft. coarse ore belt conveyor which delivers minus 4-inch ore to a 3 ft. x 6 ft. single deck vibrating screen in open circuit with a 3-foot standard cone crusher. A tramp iron magnet is installed over the coarse ore belt for removal of items which might otherwise damage the cone crusher. Plus 3/4-inch ore is chuted to the 3-foot cone equipped with hydraulic setting devices. Undersize from the cone and screen are combined and delivered to an 18 in. x 43 ft. fine ore belt conveyor.

This conveyor delivers oré to a motorized flopgate chute which allows the ore to be delivered to a 12 in. x 20 ft. reversible conveyor. This belt can deliver ore to either of two 250-ton live capacity circular ore bins. These bins are equipped with bin level indicators to provide warning prior to overflow.

Grinding and Concentrating

The grinding and concentrating section of the mill is based on a three shift twin circuit operation. The twin circuits allow for half production in the event of failure of a critical item of machinery in either branch.

Each circuit is based upon 250 ton-per-day, three shift capacity. In each case, ore is delivered by 12 in. x 20 ft. weighing belt feeders with variable speed drive. These deliver ore to two 7 ft. x 8 ft. ball mills operating in closed circuits with a 16 in. x 24 in. duplex jig and 54 in. x 19 ft. spiral classifier each. Concentrate from the jigs is removed and transported by launder to one 42 in. x 38 in. amalgamation unit for removal of gold content. The classifiers overflow at 25% pulp density and minus 65 mesh ore to twin flotation circuits. Overflow is conditioned in two 4 ft. x 4 ft. conditions. Concentration of bulk sulphide is effected in twin circuit 6-unit 56 in. x 56 in. flotation cells. Concentrate is laundered to a 6-foot diameter by 5-foot deep thickener. Thicker pulp is pumped to a 4-foot diameter by 4-foot disc vacuum filter, located over a 10-ton filtercake storage bin. This bin receives filtercake directly from the scrapers by gravity and has a capacity adequate for one day. Filtercake is transported to a 24 in. x 15 ft. hot air rotary dryer by a 6-inch diameter screw feeder. After drying, the concentrate is elevated by a 5 in. x 3½ in. x 15 ft. high belt-bucket elevator to a 2-day capacity, 20-ton concentrate storage bin. From here, concentrate is put into 50 gallon drums and stored for shipment.

Tailings are combined from the twin flotation circuits and laundered to a 15 ft. x 8 ft. thickener for water reclamation purposes. Fresh water overflows into a 5,000 gallon clear water sump which also receives make-up water. Recirculating water is pumped to the circuit and a jig head tank by a 3 in. x 3 in. pump. Thickener underflow is pumped by a diaphragm pump to a 5 ft. x 5 ft. tailings agitator, from which it is pumped by a 3 in. x 3 in. pump to the disposal area.

Amalgamation

Amalgam is removed from the amalgamator and retorted for gold recovery. Tailings from this unit are laundered to a 3 ft. x 3 ft. ball mill in closed circuit with a 9 in. x 7 ft. x 10 in. spiral classifier. Classifier overflow is split and sent to the twin flotation circuits.

The flowsheet for the above operations is shown in Figure 11 (in pocket).

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OPERATING COSTS

General Statement

The Fairbanks lode mining district falls entirely within the Fairbanks-North Star Borough, Alaska. The University of Alaska has just completed a research project on the costs and prices in the Fairbanks-North Star Borough _/ 14 and the published report states the following conclusions:

> "Regional markets and business operating costs. The local industry base is a very small segment of overall economic activity. These construction and manufacturing firms remain substantially dependent upon government construction contracts. Local business necessarily purchase factors of production, e.g. land, buildings, labor, at prevailing prices and wages. Historically these prices have been substantially inflated. In addition, very few of the products sold in the region are produced here. Accordingly, businesses incur substantial costs of transportation in buying inventories. An examination of transportation costs explained only a very small proportion of the inter-city retail price differentials. Manhour labor costs have increased at roughly 5 per cent annually. Since 1957, in large part, these wage increases have been offset by productivity gains, i.e. higher sales per man-hour in physical distribution and increasing output per man-hour in

manufacturing. Most Fairbanks businesses still must operate with relatively short peak work seasons. This situation is directly attributable to the physical environment. These short seasons do cause an increase in costs of business operations in comparison to mild climate regions.

Overhead expenses incurred by firms, e.g. particularly fire and liability insurance, utilities and costs of capital, were surveyed. These overhead costs were seriously higher than reported by similar firms of comparable size elsewhere. Gross profit margins remain substantial for most marketing institutions to compensate for these overhead costs. Fairbanks businesses face a difficult problem in attaining certain measures of efficiency, such as sales to inventory ratio. It is a problem of acquiring a sufficiently large scale of operations to reduce the financial impact of overhead costs. Seasonal changes in sales, transportation lags, needed lot sizes for efficient purchasing and a meager market density all reduce the ability of dealers to cut selling prices. Although retail prices might be reduced in many durable good lines, a substantial lowering of selling prices is not likely to occur in the case of food and many non-durable goods.

Non-military public employment in the borough is very large, and this segment of the economy was examined. Wages of public employees have increased as rapidly as the union wage scale in construction and manufacturing. To a large extent, the prices of public services are reflected in taxation and public utility 'products'. The consumer and industrial costs of public utility services are seriously and questionably higher than the other Alaska cities. In addition, since 1960 the rate of sales taxation has increased."

This statement, in a general way, sums up the price-cost situation in the Fairbanks district. It is not the purpose here to investigate the background and reasons for this situation, but as costs are the essential factors of this report, and since they are unique in the Fairbanks district, a detailed analysis is warranted. The operating costs that pertain to lode mining are analyzed in this section under the following headings:

(1) Labor

(2) Freight and Transportation

(3) Materials and Supplies

(4) Power

(5) Taxes

The relationship of these operating costs in the Fairbanks district with these prevailing in the western states is reported in the section on Cost Factor Analysis. Capital investment costs are discussed in the section Capital Expenditure.

There are no lode mines currently producing in the Fairbanks district that have an operating costs breakdown worthy of citation. Therefore the cost figures used in the following sub-sections have been obtained directly from various sources in literature, estimates based upon information supplied by literature, or from personal communication with individuals who are specialists.

Labor

There are two factors involving labor that are of vital concern to any employer - cost and availability.

Availability of Labor

Labor availability in Alaska is obviously greater in the proximity of the major population centers. Because of the climate fluctuations in most of Alaska, greater activity in the labor intensive industries, such as contract construction, occurs during the summer season. During the winter a high level of unemployment exists despite a general exodus of seasonal workers to the south. Unemployed workers usually migrate to the cities to seek jobs for the winter, or else depart to other areas in the United States, providing they have money enough to do so.

The Alaska Department of Labor publishes statistics on employment in Alaska by area and by industry type. In addition, unemployment statistics regarding the number of employment office referrals to jobs and unemployment insurance rates and activity are detailed. _/ 9 No breakdown by Alaska area on industry type is made for unemployment; consequently, there is no direct method of determining mining labor availability for the Fairbanks district. In general, it may be stated that experienced underground mining labor is in short supply in Alaska and, also, that any company contemplating Alaskan mining must be prepared to recruit and train workers for its mine. Despite the indicated poor labor availability, Alaska's year-around coal mines have not been plagued by labor shortages. The high total pay due to overtime work and job stability actually places labor availability as one of the mine management's minor problems. Although new employees have to be trained, this is accomplished through on-the-job experience. The general level of formal schooling of those employed is high and their "work attitude" is excellent.

A source of able-bodied workmen exists in Alaska's indiginous population - the native Indians and Eskimos. These people comprise 20% (45,000 person) of Alaska's population. _/ 24 The capability of native Alaskans to adapt and learn has been demonstrated by past experience in both placer and hard rock mining. An enlightened management can achieve good results in hiring and training these people.

Several northwest Canadian mines and one northern Alaskan mine successfully use a high percentage of native workmen, and an attempt is being made to train more of these people in vocational courses. In Alaska, formal schooling is available in most remote villages, and a vocational training program exists.

Estimates of labor availability and productivity for mines in much of Alaska are, at best, difficult to make. However, experience shows that when employment opportunities are created, even in remote areas, at least a partial labor force appears where none apparently existed previously. Difficulties encountered in maintaining a labor force in mining demonstrates that increased planning "for people" is required. Obviously, additional costs are incurred which the project must bear.

In summary, it can be said that a small lode operation requiring ten men or less would be able to draw from the local available labor force enough skilled or semi-skilled miners to maintain year-around production providing wages were adequate. Larger operations would have to take one or more of the following steps to acquire a labor force with some underground mining skill:

(1) Raise wages or salaries to the point where they are attractive enough to draw labor on a year-around basis from outside Alaska

(2) Raise wages or salaries to the point where they are attractive enough to draw labor from other industries in Alaska and train the force by means of on-the-job experience.

(3) Maintain an average wage and hire and train a labor force from the largely unemployed and inexperienced Alaska native population by means of on-the-job training.

Cost of Labor

The cost of labor may be divided into several categories. These are wages, costs of benefits required by law, and costs of other fringe benefits. The assumption is made here that any labor force being maintained by a lode operation of the sizes being discussed will ultimately be unionized, and all the above labor cost categories are applicable.

Wages

Mining wages in Alaska do not reach the level set by construction and government facilities. There are no figures from which to base a good average underground metal mining wage scale; in lieu of this, the following average earnings of gold placer and coal mining operations are summarized and compared with contract construction:

TABLE 2. Summary and Comparison of Employment and Earnings of the Mining (Placer and Coal) and Contract Construction Industries in Alaska _/ 14

INDUSTRY	YEAR	EMPLOYEES	AVERAGE WEEKLY EARNINGS	AVERAGE WEEKLY HOURS	AVERAGE HOURLY EARNINGS
Mining	1960	1,100	-	-	-
	1961	1,200	$167.96	49.4	$3.40
	1962	1,200	175.55	48.9	3.59
	1963	1,200	174.84	47.9	3.65
	1964	-	-	-	3.52
Contract Construction	1960	5,900	-	-	-
	1961	4,100	254.19	43.6	5.83
	1962	4,000	267.16	44.9	5.95
	1963	4,200	274.67	45.4	6.05
	1964	-	-	-	6.25

A further breakdown of earnings of workers in the mining construction industries in Alaska on a seasonal basis:

TABLE 3. Summary and Comparison of Earnings of Workers in the Mining (Placer and Coal) and Contract Construction Industries in Alaska in 1964 _/ 14

MONTH	AVERAGE HOURLY EARNINGS ($ PER HOUR) MINING	CONTRACT CONSTRUCTION
January	$3.59	$6.09
February	3.57	6.12
March	3.43	5.93
April	3.27	6.11
May	3.26	6.11
June	3.14	6.10
July	3.30	6.11
August	3.56	6.27
September	3.57	6.51
October	3.78	6.42
November	3.89	6.64
December	3.89	6.55
1964 Average	3.52	6.25

The above averages of earnings in the Alaskan mining industry are reported merely to emphasize the comparison with a typical season industrial-contract construction. The figures for mining are not suggested as being typical of what would be expected for an underground lode operation.

As previously expressed, the exact wages that might be expected to attract a labor force to a lode operation would be partially dependent upon the size of the labor force required, i.e. the daily production of the mine would determine the number of men required, the source of this labor, and consequently, the standard of wages required to attract them. However, for the sake of the problem at hand, it is necessary to specify an exact wage scale for all positions in a lode operation with a minimum of complications. The following scale is the result of union-management negotiations for a single underground coal mine in 1964 in Alaska, and it is considered as being reasonable for average wages to be expected for all situations in this report. This wage scale will be used as the basis for labor costs in the section on <u>Minimum Values and Tonnages</u>.

TABLE 4. Expected Wage Rates for Labor in Underground Lode Operations, Fairbanks District, Alaska _/ 5

POSITION	HOURLY WAGE
Miner	$ 5.025
Timberman	4.575
Motorman	4.575
Miner's Helper (mucker)	4.575
Hoistman	4.575
Surfaceman	4.125
Nipper	4.575
Millmen	4.575
Millwright	4.675
Blacksmith	4.575
Carpenter	4.575
Electrician	4.575
Machinist	4.575
Mechanic	4.575
Mechanic's Helper	4.325
Lampman	4.325
Truckdriver (up to 20 yards)	4.325
Truckdriver (over 20 yards)	4.405
Cook	4.06
Dishwasher	2.475
Bookkeeper	650/month
Accountant	1,050/month
Clerk	500/month
Payroll Clerk	750/month

In addition to wages for hourly employees, it is also necessary to select a base for salaried employees of the management and engineering staffs. These expected earnings will also be dependent upon the size of the operation (or the extent of the individual's responsibility). Since there would be a variance in salary due to responsibility, the salaries are expressed in ranges. Some of the positions noted would only apply to large operations. For instance, a 50 ton-per-day lode operation would not require both a mine superintendent and mine foreman. However, a 500 ton-per-day operation would likely require both.

TABLE 5. Expected Salaries for Management and Professional Services in Underground Lode Operations, Fairbanks District.

POSITION	SALARY ($ PER MONTH)
Mine Manager	$1500 - 2000
Mine Superintendent	1100 - 1600
Mill Superintendent	1100 - 1600
Mine Foreman	1000 - 1400
Assistant Mine Foreman	900 - 1200
Shift Foreman	800 - 1100
Mine Engineer	1000 - 1500
Mine Geologist	900 - 1400
Assayers and Surveyors and Samplers	900
Office Manager	900 - 1400

The State of Alaska Statutes (AS 23.10.060) require that all work in excess of 8 hours per day and 40 hours per week be classified as overtime and be payable for at a rate 1½ times the regular hourly rate. Exceptions to this are small operations with less than 12 men where the working hours are less than 12 hours per day, and this condition does not exist for more than 14 weeks. Also, no worker is permitted to work more than 8 hours underground in one shift (AS 23.10.410).

Costs of Labor Benefits Required by Law

This section of labor operating costs will involve the expense to a lode operation due to:

(1) Social Security Tax (FICA)

(2) State of Alaska Unemployment Security Tax

(3) Federal Unemployment Tax

(4) Workmen's Compensation Premiums

These payroll taxes or premiums are all required by either Alaska State or United States law and represent a very real cost to the operator.

Social Security

Social Security taxes as defined by the Federal Insurance Contributions Act are taxes on the wages of all employees for the purpose of old age, health, survivor, and disability insurance purposes. The tax levy is 4.2% of the first $6,600 of the employee's wages. _/ 23 This amount is paid by both the employee and the employer, or a total percentage of 8.4%. The employer is responsible for withholding the employee's contribution and submitting it with his own portion at the end of each quarter year.

"Wages" as defined above include:

(1) Regular hourly payments to the employee (or salary)

(2) Overtime payments to the employee

(3) Vacation allowances to employees

(4) Retroactive wage increases

(5) Bonuses

State of Alaska Unemployment Security Tax

In general, individuals, companies and organizations who have one or more workers in covered employment for any part of a day, are liable for contributions (taxes) under the Alaska Employment Security Law, AS Title 23 Chapter 20. Employers involved in mining operations are liable under this law; engineers, foreman, and other professional employees or management personnel are considered employees in regards to this law.

Unemployment insurance provides a source of weekly cash benefits for workers who have lost their jobs, but are able to work and available for work if the employment were available. Benefits are based on the amount of wages earned from liable employers during a worker's "base period" consisting of the first four of the last five calendar quarters immediately preceeding the quarter in which the initial claim for benefits is filed.

The employer pays the main share of the tax, but the employee must also contribute a portion. The employer withholds the employee's share, adds his own portion, and submits the total at the end of each calendar quarter.

Tax rates for employers are variable between 1.5% and 4.0% of the first $7200 in wages of the employee for each calendar year. For employees, the rate varies between 0.3% and 0.9%. Standard tax rates are 2.9% for employers and 0.6% for employees. The exact percentage depends upon the payroll experience of the employer. If he is just starting a business, he will be assigned the standard rate. After several years when he has established a payroll experience rating, his tax rate may be altered. In general, the more consistant his payroll - the less his tax rate. _/ 7

Federal Unemployment Tax

The unemployment tax as defined by the Federal Unemployment Tax Act is levied upon employers only. The tax represents 3.1% of the first $3000 in wages paid to employees. "Wages" are defined in the same manner as those subject to

Social Security Tax. However, up to 2.7% of wages that are paid as State Unemployment contributions may be deducted from the amount due on the Federal Unemployment Tax. This tax is payable at the end of each quarter year. _/ 23

Workmen's Compensation Premiums

The authority for the Workmen's Compensation Act is AS Title 23, Chapter 30. All personnel involved in a mining operation are included under the provision of this statute.

The purposes of the Workmen's Compensation Act are:

(1) To provide support for those made destitute by death of their provider.

(2) To do away with the old disputed questions of negligence and assumption of risk, and to do away with juries' findings as to the amount of damages recoverable.

(3) To provide injured employees with a specific recovery for specific injuries.

(4) To provide a simple and inexpensive remedy for claimant benefit.

The Act states:

"An employer is liable for and shall secure the payment to his employees of the compensation payable under the provisions of this act. An employer under this chapter unless exempted, shall either insure and keep insured for his liability under this chapter in an insurance company or association duly authorized to transact business of workmen's compensation insurance in this state, or shall furnish the board satisfactory proof of his financial ability to pay directly the compensation provided for. If the employer elects to pay directly, the board may, in its discretion, require the deposit of an acceptable security, indemnity or bond to secure the payment of compensation liabilities as they are incurred."

Rates for workmen's compensation insurance as charged by duly authorized insurance companies are based upon a certain percentage of each $100 of payroll in accordance with the risk involved with the employee's work. For instance, the following examples are to be used in calculations in a later section of this report: _/ 2

Type of Occupation	Premium ($ per $100 of Payroll)
Surfacemen	$ 3.73
Undergroundmen	11.28
Millmen	5.28

Since policies for small operations are under the category of assigned risk, the premiums for the same occupation may vary from one operation to another.

Other Fringe Benefits

Assuming that the operation is large enough to attract unionization, it is probable that the following fringe benefits will have to be supplied by management to its employees:

(1) Vacation pay

(2) Hospital - medical insurance

(3) Retirement compensation

(4) Shift differential

As the above benefits would be the result of negotiation, only estimated costs to an employer can be considered. Therefore, the following estimates are considered as being probable:

(1) Vacation pay - 10 shifts per year at straight time wages.

(2) Hospital - medical insurance - Costs to be borne equally by employer and employee at

the rate of $15 each per month. This figure is an average, as it would vary with the number of employee's dependents.

(3) Retirement compensation - On the basis of a plan existing at an Alaskan open pit coal mine, the cost to the employer is relative to the tonnage mined. Twenty cents (20¢) per ton is selected to go into a retirement fund. _/ 5

(4) Shift differential - No precedent has been established for Alaskan metal mines, therefore the following assumption is made:

Afternoon shift - 10¢ per hour extra
Night shift - 15¢ per hour extra

On the basis of the rates outlined above, the total direct costs per shift for all types of labor are given in Appendix I, for each shift. It is assumed that all labor will work six days a week, on portal-to-portal pay, and receive premium time for the sixth day. Operations requiring shift work will rotate labor between the shifts periodically.

Freight and Transportation

Freight and transportation costs and availability are basic problems which affect the feasibility of any mineral resource development scheme. In Alaska, freight tonnages of adequate size to sustain a transportation firm are limited to the population centers. The lack of consistant backhaul tonnage is a problem, and consequently, freight costs are high.

Transportation costs for personnel between Alaska and the other states are high because of the distances involved, the large necessity for air transport, and the limited number of passengers involved. Costs for intra-state transportation of personnel are in proportion with the cost of living except when destinations require aircraft charter for service.

Freight Haulage

As this report is concerned only with relatively small amounts of gold and silver bullion and relatively small tonnages of concentrates (10 tons/day maximum) as products of mining, the effects of freight costs are minimized. That is, there are no large tonnages of concentrates to be shipped. The main concern here is the cost of freighting equipment and supplies from the supplier to the mine or mill.

Since there are no local sources of heavy specialized mining and milling equipment for underground operations in the Fairbanks district, such as rail cars, ball mills, mucking machines, or locomotives, this machinery must be purchased from the western states and freighted to Fairbanks. Since the cost for this freighting is high, it is an important expense to be added to the purchase price of the equipment.

Methods and Routes of Freight Haulage

Alaska is served on a scheduled basis by transportation companies with one or more of the following structures:

(1) Truck-trailer container vans are loaded on ocean freighters sailing between Seattle and Anchorage on a weekly schedule. Vans are loaded off at Anchorage for delivery to any point on the Alaska highway system by truck, or they may be loaded at the Anchorage dockside onto Alaska Railroad flat cars for delivery to railbelt locations. _/ 20

(2) Direct railroad car-barge service is scheduled every three days between Seattle and Whittier. The railroad cars are loaded off at Whittier and delivered along the railbelt of the Alaska Railroad. At railbelt locations, the contents of the railroad cars may be reloaded onto truck-trailers or river barges and transported to their final destination.

(3) Weekly delivery of railcars can be made at Valdez by the barge system, although no railroad connections can be made there.

(4) Direct truck-trailer service via the Alaska Highway from Seattle to Alaska points is scheduled twice weekly by two companies. Two companies also operate river tug and barge services on inland riverways during the summer. _/ 12

(5) Four scheduled air carriers operate freight hauls out of Seattle to major Alaska cities, but heavy freight (over 5 tons) must be contracted.

(6) Scheduled steamship freight service is available from Seattle to Alaska ports. A cooperative arrangement with the Alaska Railroad for delivery to railbelt areas has been available since about 1920.

In addition to the major transportation systems described above, many small operators contract freighting business in Alaska.

Freight Costs

As indicated above, there are several alternatives in methods of transporting freight to Alaska on an all-year-around basis. The three major combinations are noted below in Table 6 with corresponding costs per ton of cargo from Seattle to Fairbanks. The costs per ton for other systems are not quoted but they appear to be no more than competitive.

TABLE 6. Approximate Freight Rates for Mining Machinery from Seattle, Washington to Fairbanks, Alaska.

MEANS OF TRANSPORTATION	CARGO WEIGHT RANGE	COST/TON	REFERENCE
Truck - trailer (Alaska Highway)	0 - 25 Tons	$170	Lynden Transfer Inc.
Air Freight	0 - ½ "	320	Alaskan Airlines
	½ - 1 "	300	
	1 - 1½ "	290	
	1½ - 2½ "	280	
	2½ - 5 "	270	
Railroad - trainship or Steamship	0 - 5 "	110	Alaska Railroad
	5 - 20 "	90	
	20 - 25 "	74	
	25 - 30 "	64	
	30 - 35 "	58	
	35 - 40 "	54	
	40 - 45 "	51	
	45 - 50 "	50	

To compute the cost of equipment f.o.b. Fairbanks, it is necessary to add the Seattle - Fairbanks freight charges to the purchase price f.o.b. Seattle plus any additional handling charges. Handling charges are indefinite and are, therefore, not quoted. However, the local mine operator may not have equipment appropriate for handling and transporting heavy equipment and supplies to the mine site. Therefore, local freighting cost in the Fairbanks district is of some importance.

Since the historical areas of lode mining in the Fairbanks area are within 30 miles of the city of Fairbanks, and already traversed by both primary and secondary road systems, the use of truck transportation locally poses no particular problem.

Cost of local freighting in the Fairbanks district is based upon hourly rates. On the basis of $25 per hour for freight handling and transportation time between the hours of 8:00 a.m. and 5:00 p.m. on a lowboy, _/ 16 the cost per ton from Fairbanks to Cleary Summit would approximate $5 per ton for a 20-ton load, or $0.20 per ton-mile. The cost to the Ester area would be less, approximating $3.75 per ton, but the cost per ton-mile would be $0.25 per a 20-ton load. The rate of trucking cost to Ester is higher per ton-mile because a greater proportion of the total contract time is involved in handling. Smaller loads would raise the cost-per-ton proportionately.

Personnel Transportation

As explained in the subsection on Labor, any underground mining operation employing more than 10 skilled workers would have to draw its labor force from outside the Fairbanks district. This would necessitate the transportation of personnel and their families to Fairbanks. Therefore, personnel transportation availability and fares are of some importance to the mine operator.

Methods and Routes of Personnel Transportation

The following means of transportation are available for personnel travelling to or within Alaska:

(1) Automobile travel via the Alaska Highway is available on a year-around basis. From Seattle via Vancouver and Prince George, British Columbia, the Hart Highway, and the Alaska Highway the trip covers 2365 miles, of which 1140 is gravel road.

(2) Automobile travel via the State Ferry System is also available all year around. Approximately 650 miles of driving is eliminated by taking the car ferry from Prince Rupert to Haines rather than the full Alaska Highway. Road connection is made to Fairbanks from Haines via the Haines and Alaska Highways.

(3) Several airlines provide direct flights between Seattle, Chicago, Whitehorse and Alaskan points. Most of the flights are on a daily schedule. Intra-Alaska scheduled flights are also available several times weekly between the major towns and cities.

(4) Aircraft may be chartered within the state on a wide range of type and capacity. Alaska is noted for having an extensive air-charter system with rates depending upon distance or hourly flying time and type of aircraft.

(5) The Alaska Railroad is available for personnel transportation between Seward and Fairbanks and all points on the railbelt between. A daily schedule is maintained during the summer months, while the run is made several times a week during the winter.

(6) Bus transportation via the Alaska Highway to Fairbanks is available all year around. Connections can be made with the State Ferry System and Canadian buses in British Columbia.

Costs of Personnel Transportation

The major carriers for personnel transportation are listed below in Table 7 with their corresponding fares from Seattle to Fairbanks, or Anchorage to Fairbanks:

TABLE 7. Carriers and Fares for Personnel Transportation between Seattle, Washington, or Anchorage and Fairbanks, Alaska.

	COST TO FAIRBANKS			
	FROM SEATTLE		FROM ANCHORAGE	
CARRIER	INDIVIDUAL	VEHICLE	INDIVIDUAL	REFERENCE
Automobile (via Alaska Highway)	$100	$100	-	"Milepost"
Automobile (via State Ferry)	125	180	-	"
Airlines	100	-	$37	Alaska Airlines
Bus	102	-	21	Alaska Coachlines
Railroad	-	-	21	Alaska R.R.

Materials and Supplies

An indication of price relationships between cities in the United States is given by Consumer Price Indexes. The base for these indexes may be an average value of a group of selected commodities in all cities in the country during a certain year, or possibly, an arbitrary value representing the costs of a selected group of commodities in just one city. A commonly used base for comparing commodity prices in Fairbanks is the price level of similar items in Seattle, Washington. For instance, the price level of a group of commodities in Seattle was arbitrarily set at 100 for each year between 1960 and 1964, and the following price levels were indicated by costs in Fairbanks: _/ 14

Year	Relative Cost of All Items Except Housing in Fairbanks When Seattle Cost is 100
1964	128
1963	128
1962	127
1961	127
1960	128

The increased costs of goods in Fairbanks are attributable to several factors, some of which are evident in this section, such as high costs of labor, transportation, and power. There are others which will not be discussed here. In any case, a listing of the costs of some supplies and materials that are pertinent to mining operations is justified on the basis of the high costs, and also, because a reference is necessary for establishing total costs of mining and milling in the Sections on Cost Factor Analysis and Minimum Values and Tonnages.

This subsection will briefly discuss the costs and availability of materials and supplies under the following headings:

(1) Petroleum Products

(2) Coal and Propane

(3) Building Products

(4) Miscellaneous Hardware and Tools

(5) Explosives

(6) Plumbing Supplies

(7) Electrical Materials

(8) Foodstuffs

(9) Track Supplies

(10) Underground Ventilation Materials

(11) Miscellaneous Mill Supplies

Petroleum Products

The local prices for selected petroleum products, including fuel and lubricants, are given in Appendix II. The prices quoted are based upon wholesale purchases in the containers stated. An adequate supply at these prices appears to be no problem.

Coal and Propane

The price and availability of coal are important for the selection of a fuel and design of the heating plant for the mill and other surface structures. Both stoking and lump nut coal is available in large quantities in Fairbanks at the prices indicated in Appendix II.

Blacksmith coal is no longer available in Fairbanks, and must be purchased in 100-pound sacks from Seattle.

Propane in moderately large quantities may be used for retorting gold. Availability is no problem, and the prices for large and small lot purchasing is given in Appendix II.

Lumber and Building Products

Lumber and timber prices are important factors of mine operating costs because of the large quantities used for support and railroad ties. Availability appears to be adequate due to large resources in southeastern Alaska. Most of the lumber is spruce.

Prices vary as much as 33% between suppliers, usually depending upon the quality of their particular supply on hand. Some suppliers have cheap prices but their continuity of supply is not assured. The prices given in Appendix II are an average for rough lumber with a consistent supply assured.

Insulation and other building products for surface plants are available in sufficient quantities for any mining operation.

Miscellaneous Hardware and Tools

Many tools and small equipment are necessary for a mining operation that must be relatively self-sufficient. An abbreviated list of basic tools and their cost is given in Appendix II.

A specific type or brand of hardware item may not be consistantly available in Fairbanks upon demand, but usually it can be ordered by a supplier and obtained within a week by air freight if a substitute is not satisfactory. It is advisable to order specialized equipment well in advance of its actual date of usage. Also, a machinist would be an asset to a large mining operation, and his labor costs would probably be absorbed by savings on machined parts for equipment replacements.

Explosives

There is one retailer of explosives in the Fairbanks area. Consumption in the district is relatively low, therefore the inventory is low and the costs are high. Prices for available explosives and accessories are given in Appendix II. Special items, not in stock, can be ordered upon request. It is likely that prices could be reduced by obtaining carload shipments from the manufacturer if the usage and storage facilities warranted.

Plumbing Supplies

Activity in local building construction warrants a reasonable inventory of plumbing supplies in Fairbanks. The sizes and types of materials for a mining operation are available in limited quantities, but large lot purchasing should deserve advance notice to the supplier. It is possible that large purchases could be made in Seattle and freighted in one lot to Fairbanks at a lower total cost. Appendix II lists some selected prices.

Electrical Materials

There are several outlets for common electrical supplies and materials in Fairbanks, but specialized equipment, such as transformers and switches, motors and generators, may require special ordering from outside the state. Some selected electrical supplies for general usage in a mining operation are listed with costs in Appendix II.

Foodstuffs

Food prices in Fairbanks average about 40% above those in Seattle, _/ 14 however, annual increase in price is consistant with the inflationary increase in Seattle. Wide varieties of all foodstuffs are obtainable in the city and a few small grocery stores supply essential items in the district surrounding. Some selected items are priced in Appendix II.

Track Supplies

There is no supplier in Fairbanks for mine rail, spikes, splice plates, turnouts and other track materials and equipment. These items must be purchased from the western United States and freighted to Fairbanks. The prices quoted in Appendix II are on the basis of purchase in Seattle with included freight charges to Fairbanks.

Underground Ventilation Supplies

Ventilation tubing and blowers are not available in Fairbanks. They must be ordered from outside the state. Prices of vent tubing f.o.b. Fairbanks are given in Appendix II.

Miscellaneous Mill Supplies

There is no supplier of flotation or cyanidation reagents in Fairbanks. These supplies, along with other standard expendable mill items such as ball mill liners and balls, and liners and surface plates for crushers, must be obtained from the western states. Acquisition of these materials should offer no problem, however, as they are used on a scheduled basis, and ordering can be done systemmatically.

Generally, most materials and supplies for everyday operation of the mine, exclusive of capital equipment, are available to limited extent in Fairbanks. Milling equipment and supplies are special orders. All specialized equipment will usually require advance orders to suppliers in Fairbanks or the western states. Large quantity purchasing, of course, will result in lower prices, especially if on a consistent basis, due to cheaper freight rates and cheaper supplier prices.

The prices of materials and supplies given in Appendix II are the prices for goods as they can be purchased in Fairbanks, or the cost of buying elsewhere and shipping to Fairbanks, by the general public without contractural agreements. Wholesale prices are given where possible, but normally they represent higher prices than those that would actually be paid by a mine operator.

Power

Generally, modern underground mining equipment uses one or more of the following major sources for power:

(1) Compressed air

(2) Electricity

(3) Direct diesel

Other sources, such as gasoline engines and steam turbines, may find their way into parts of the surface operations, but their use underground is either prohibited or not practical. It is usually most economical and practical to select sources of power of a single nature that will operate as many items of equipment as possible.

Compressed Air

Although compressed air is not truly considered a primary source of power due to its dependence upon electricity or diesel, it is an essential power provider and may be used to operate pumps, rock drills, core drills, blowers, mucking machines, slushers, locomotives, and a variety of small tools. Its advantages make it an unquestionable selection of power in a lode mining operation.

Electricity

Electricity may be categorized as follows:

Direct Current

(a) Generated
(b) Battery

Alternating Current

Generated direct current has limited uses in small lode operations, except for charging miner's lamps and battery locomotives. However, the generated direct current in these cases is usually derived from rectifiers in an alternating current circuit. Large operations may use generated direct current for hoist motors because of its good control characteristics. It is also popular in coal mines as a means of power for trolley locomotives.

Battery direct current for locomotives has the advantage of savings on fuel and fuel delivery costs. This may be a factor for consideration in an area such as Fairbanks.

Alternating current is an essential source of power. With the exception of rock drills, mucking machines, and locomotives, all other underground equipment may be operated by AC power. If for no other reason, it is necessary for lighting circuits. Direct current is obtained from it for charging miner's lamps, synchronous motor fields, and other minor items. AC induction motors are conventional for hoisting in the sizes of operations being considered.

Alternating current may be obtained in either single or three phase from two sources:

(1) Power company transmission lines

(2) Diesel electric unit on the mine site

Electrical power is transmitted in the vicinity of both of the historical lode mining areas of the Fairbanks district. It is probable that connecting transmission lines to the mine site, however, will involve considerable capital expense. The mine operator must absorb this expense since mining is not considered at this time to be stable enough for a power company to be willing to speculate on amortizing the expense through future power charges. This attitude, however, might change with the circumstances. A minimum expense of $5,000 could be expected, for an average situation.

A variety of voltage is available from the transmission lines around Fairbanks, including 120/208, 120/240, 240, 2400, and 4160. Charges for electrical service are divided into two categories:

(1) Maximum demand charge

(2) Energy-consumed charge

This demand charge is placed under contract between the consumer and the power company and it stands as the minimum monthly charge thereafter, regardless if energy is consumed during the month.

The General Use Schedule 16 of the Golden Valley Electric Association (a Rural Electric Association) states the following rates for maximum demand charges: _/ 13

Demand	Charge Per KW
First 100 KW	$3.25
Next 400 KW	3.00
Over 500 KW	2.90

There is a penalty on demand charges for a power factor below 85%. Demand charges for circuits with power factors below 85% will be multiplied by the ratio of 85% to the actual power factor existing.

Energy-used charges are based upon the theory of decreasing rates for higher consumptions of electricity. GVEA states the following rates on Schedule 16:

Energy Used	Charge Per KWH
First 10,000 KWH	4.0 ¢
Next 10,000 KWH	3.75
Next 80,000 KWH	2.50
Over 100,000 KWH	1.50

The alternative to power company transmission is the diesel electric plant. The main disadvantage to diesel electric is the large capital investment necessary, since a standby unit is essential if a continuous operation of the mine and plant is to be assured. On the month-to-month basis, the operating cost, including depreciation, may be competitive, but the initial capital must be secured. Transmitted power costs are high, as indicated by the comparison below, so an analysis of the particular situation is warranted as large savings could result: _/ 14

City	Overall	Charges per 1000 KWH According to Classification of User, 1962		
		Residential	Commercial	Industrial
Fairbanks	$50.80	$54.60	$127.68	$58.70
Seattle	9.23	9.53	12.81	5.52

Direct Diesel

Direct diesel in a lode mining operation of the size range being considered is generally limited to locomotives or compressors. If electrical power is already available, synchronous motors are better for air compressor power. Diesel locomotives are most applicable for mainline haulage in small lode operations, but there are certain restrictions upon their use as stated in the State of Alaska Mine Safety Regulations 2559.42. Diesel engines cannot be run when the ventilating fans are not operating. They must be equipped with exhaust conditioners (scrubbers) to keep the exhaust temperature below 180 degrees at the point where it meets the mine atmosphere. The latter is no problem, as this is usually standard equipment on underground locomotives.

Although not considered as a source of power in this section, steam is worthy of mention as a means of heating. Coal is readily available from the Alaska coal fields, and therefore steam heating promises a very competitive system. Heating is a serious consideration as it may involve numerous buildings such as the mill, dryhouse, office, compressor house, shop, and garage which may be spread considerable distances apart. Steam lines in combination with heat exchangers and circulating water in the individual buildings is considered to be a good system.

Taxes

In the Fairbanks district, there are four government bodies that impose taxes as a source of revenue. They are:

(1) The Federal Government

(2) The State of Alaska

(3) The Fairbanks-North Star Borough

(4) The City of Fairbanks

State and federal taxes are generally imposed throughout the district. The Fairbanks-North Star Borough taxes also apply to the territory within the City of Fairbanks and the City of North Pole. City of Fairbanks taxes are confined to the area defined by the city limits.

The only tax categories discussed in this section are those that might conceivably pertain to the operation of a lode mine in the district.

Federal Government Taxes

Mining is profit motivated and its income is taxed by federal law similar to any industry or business. There are, fundamentally, only two types of income tax assessment - the individual and the corporate. The tax is a percentage of net income as set by law. The individual rate applies to sole proprietorships and partnerships, and the corporate rate applies only to legally incorporated forms of business organizations.

In addition to the rates set by law, based on the form of business organization, special regulations apply to various areas of business activity. Mining (Business Activity Code #1120) has such regulations since it is recognized by law as a depleting-asset industry. The main feature of these regulations is a provision for a depletion allowance as an expense chargeable against gross income. The funds thus available enables mining firms to locate new ore reserves to replace those being mined (In 1966 Form "M" for depletion allowance calculation must be submitted with tax forms). The depletion allowance assists in stabilizing the industry by making funds available for prospecting, thus assuring a continuous supply of minerals, raw materials, and fuels for society's use.

Since mining is a capital intensive industry, and for other reasons, it is assumed that the corporate form of business organization best suits the requirements of a mining firm.

The 1966 rates for federal income tax on corporations are stated as a normal tax rate of 22% of all taxable income plus a surtax rate of 28% on taxable income over $25,000.

Following is an example of federal income tax calculation for a small lode mine. It is simplified to illustrate the principles involved. In actual cases, mine managers should seek professional tax and accounting assistance since regulations change and the subject is a complex one.

Gross income from property........	$100,000	
Deduct all operating costs, including depreciation.............	75,000	
Net taxable income before depletion...........		$25,000

Depletion allowance

Two methods of computing depletion exists. The first and oldest is cost depletion and it is of minor importance. The second is percentage depletion which is 15% of gross income for gold, subject to the limitation that the allowance shall not exceed 50% of the taxable income computed without depletion.

Hence the depletion allowance is 15% of $100,000 or $15,000, which is subject to the test that $15,000 is not to exceed 50% of the taxable income, or:

50% of $25,000 = $12,500 which is the maximum allowable deduction.

Therefore, the 15% of gross income exceeds the 50% of taxable income and the depletion allowance is limited to $12,500.

Depletion.........................	12,500	
Net taxable income...........................		$12,500
Tax: 22% of $12,500...........................		2,750

Note: If net taxable income were over $25,000, tax would be computed as 22% of Net Taxable Income plus 28% of any amount over $25,000.

State of Alaska Taxes

There are several taxes imposed by the State of Alaska upon mining operations, or that are the responsibility of the mine operator to collect and submit for employees. Those imposed upon the mining operation are:

(1) Corporation income tax

(2) Motor fuel tax

(3) Mining license tax

In addition to the employee's share of the State of Alaska Unemployment Security Tax, an employer must withhold from the employee a School Tax of $10.00 per year, and submit both to the State. The authority for the School Tax is AS 43.45. The employer must also withhold personal state income taxes from his employees. This is authorized by AS 43.20, and amounts to 16% of the value of the federal withholding tax for each individual. This withholding must be submitted quarterly.

State of Alaska Corporation Net Income Tax

Alaska Statute 43.20 states:

> "There is levied and there shall be collected and paid for each taxable year upon the net income of every resident and nonresident corporation that is required to make a return and pay tax under the federal income tax law a tax equal to 18% of the total income tax that would be payable for the same taxable year to the United States at the federal tax rates in effect on December 31, 1963, under the provisions of Chapter 1 of Subtitle A of the 1954 Internal Revenue Code, Public Law 591, 83rd Congress, 2nd session, as amended, upon all income derived from sources within the state."

The tax that is to be paid under this law is not deductible from gross income in determining net income. Income is defined as:

(1) Income from real or tangible property in the state

(2) Income from business, trade, or profession, and compensation for services rendered

(3) Income from stocks, bonds, notes, bank deposits, and other tangible personal property having a business or taxable situs in the state

(4) Rentals and royalties for the use in the state of patents, copyrights, or formulas

(5) Income received from outside the state including interest and dividends

Motor Fuel Tax

There are two motor fuel taxes outlined in Alaska Statute 43.40. They are distinct only by the destination of the proceeds of the revenue. The total tax for motor fuel, as used in a mining operation is 8 cents per gallon, with 6 cents of this being refundable for fuel used in off-the-highway vehicles or stationary internal combustion engines.

Mining License Tax

Alaska Statute 43.65 states:

"A person prosecuting or attempting to prosecute, or engaging in the business of mining in the state shall obtain a license from the Department of Revenue. All new mining operations are exempt from the tax levied by this chapter for three and one half years after production begins."

The amount of this tax levy or license is dependent upon the total net income for the year:

Net Income	Tax
Over $40,000 but not over $50,000	3% of net income
Over $50,000 but not over $100,000	$1,500 plus 5% of excess over $50,000
Over $100,000	$4,000 plus 7% of excess over $100,000

Net income is defined as the gross income (including royalties) less deductions for treatment, processing, and operating expenses, depreciation, taxes (sales, property, and payroll), losses sustained, and depletion.

Deductions are not allowed for federal income taxes. Depletion allowance is 15% of gross income (including royalties) for metal mines. This depletion allowance has a further limitation in that it cannot exceed 50% of the net income as calculated.

Royalties received by a lessor are considered as being the net income of the lessor's mining operation.

Mining license taxes are payable either by fiscal or calendar year. If the calendar year system is used, payment is due before May 1 of the year following. If the fiscal year system is used, payment is due within four months after the end of the fiscal year.

Fairbanks - North Star Borough Taxes

There are two taxes imposed by the Fairbanks-North Star Borough that are of interest to mining operators - the sales tax and the property tax.

Borough Sales Tax

A tax of 2% of the sales price is levied upon retail sales, rentals, and all services made within the borough. This levy is authorized by Ordinance 65-12 of the Fairbanks-North Star Borough. The maximum sales tax on any one item or sale is $20.00.

Borough Property Tax

All real property, such as land, buildings, structures, and fixtures are subjected to an annual taxation by the borough. The rate of taxation is not to exceed 3% of the assessed value of the real property. In 1966, the tax rate was $11.66 per $1000 of real property, or 1.166%. The assessed value is usually an estimate of the value that the property would bring on a sale at that time. This levy is authorized by Ordinance 64-7 and it includes mining property under the definition of real property.

Delinquent taxes on real property can eventually result in the property being lost to the borough in payment for the delinquent taxes.

City of Fairbanks Taxes

There are two taxes imposed by the City of Fairbanks, similar in nature to the borough taxes above. The Fairbanks sales tax is 3% of the retail sale price, which means that items purchased in the city will be subjected to a total city-borough tax of 5%. Fairbanks, also, imposes a tax on real property, which was at a rate of $9.60 per $1000 of assessed value in 1966. Therefore, property in the City of Fairbanks was subjected to a total city-borough tax of $21.26 per $1000 of assessed value in 1966.

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COST FACTOR ANALYSIS

Several references have previously been made to the high cost of labor and materials in the Fairbanks district as compared to Seattle or other locations in the western United States. To further illustrate this fact, Table 8 shows a comparison of 1959 mine labor costs in Montana _/ 3 with those estimated to be currently applicable in the Fairbanks district. The reader is cautioned of the 7-year lag in the Montana labor costs. However, between the years 1959 and 1964, the rate of inflation in Seattle, Washington, was averaging 1.6% per year, _/ 1 for a total of 8.0%. Therefore, one may assume that the Montana labor costs should not be currently increased more than 10% of the 1959 values. The average mine labor cost estimated for Fairbanks is 194% of that for Montana, inflation not considered. When considering inflation of 10%, the Fairbanks cost is approximately 175% of the Montana cost.

Expendable goods experience a considerable price rise in Fairbanks over the costs in the western states. This may be due to several reasons - the cost of packing and freighting, the increase in profit expected by local merchants in accordance with the cost of living, and high overhead costs in Fairbanks. The cost of explosives illustrate this statement. Dynamite, depending upon its type and strength, will usually vary between $12 and $15 per 50-pound box in the western states; in Fairbanks, the range for the same dynamite is between $21 and $24. This escalation is due mainly to the high cost of explosive transportation and handling and the low consumption in the Fairbanks area. Since explosives have high consumption rates in most mining operations, they alone will raise the overall mining costs considerably.

Most capital items would be purchased directly from manufacturers in the lower 48 states. The cost differential for Fairbanks is therefore made up mainly of the packing and transportation charges. As an illustration, several costs of selected items in Fairbanks and Montana are compared below:

Capital Item	Montana Cost	Fairbanks Cost	Cost Differential
Compressor, 360 CFM, 100 PSI	$8,000	$8,500	$ 500
Drill, jack-hammer, without air leg, 60-pound	850	900	50
Locomotive, 6-ton, diesel	16,500	18,000	1,500
Slusher, compressed air, 8 HP	2,000	2,200	200
Car, ore, Granby type, 90 CFT	1,900	2,300	400

The point of ultimate concern in this section is to show the overall result of price differentials between Fairbanks and the western states on the direct costs of mining. Direct costs must be used for comparisons that are meaningful, otherwise the results would be biased by the specific factors of production pertaining to individual mines.

Cost analysis examples of mining operations are scarce in literature. The United States Bureau of Mines has published several such analyses in recent years, _/ 2, 3 but, unfortunately, these do not approach the narrow-vein, cut-and-fill mining situation of the Fairbanks lode district. They do, however, provide suitable information for a comparison of direct costs of driving development headings. Information is provided on the relative percents of the cost of each operational phase to the total cost for headings in Idaho.

TABLE 8. Comparison of the Cost of Labor for Underground Metal Mining in Fairbanks, Alaska, and Montana.

TRADE	FAIRBANKS* BASE WAGES	FAIRBANKS* FRINGE BENEFITS	FAIRBANKS* TOTAL COST LABOR/SHIFT	MONTANA** BASE*** WAGES	MONTANA** FRINGE BENEFITS	MONTANA** TOTAL COST LABOR/SHIFT
Miner	$40.20	$12.56	$52.76	$19.12	$6.23	$25.35
Miner's Helper	36.60	11.69	48.29	18.16	5.79	23.95
Timberman	36.60	11.69	48.29	19.60	6.25	25.85
Motorman	36.60	11.69	48.29	18.64	5.94	24.58
Hoistman	40.20	12.56	52.76	18.64	6.08	24.72
Skiptender	36.60	11.69	48.29	18.16	5.79	23.95
Nipper	36.60	11.69	48.29	18.16	5.79	23.95
Electrician	36.60	11.69	48.29	20.08	6.41	26.49
Surfaceman	33.00	8.03	41.03	18.16	4.41	22.57
Lampman	34.60	8.28	42.88	18.64	4.45	23.09
Blacksmith	36.60	8.60	45.20	20.08	4.72	24.80
Machinist	36.60	8.60	45.20	20.08	4.72	24.80

Average cost of mining labor in Fairbanks = 194% of mining labor in Montana.

*Estimated costs of labor expected to be valid in Fairbanks district in 1966.

**Costs of labor valid in Montana in 1959. _/ 3

***Montana labor fringe benefits calculated as the same percentage of base wages as the corresponding trade fringe benefits for Fairbanks.

The hourly wage rates for labor, the advance per man-shift, and a full description of the heading make it possible to estimate cost results for Table 9 (a) and (b). The Fairbanks cost figures are engineering estimates. The cost figures for Idaho are those existing in 1960, and are subject to a 10% increase as explained above.

To further illustrate cost differentials between Fairbanks mining and the western states, Table 10 (a) and (b) and Table 11, were prepared. These comparisons are based upon engineering estimates of costs in Fairbanks, 1966, as stated in other sections of this report, and the costs in Montana, 1959. Again, the Montana costs may be subject to a 10% increase due to inflation. Limitations on the extent of the operations whose costs are compared in this section are given below.

Limitations on Extent of Operations for Direct Cost Comparisons

All direct costs used in the comparisons of this section relate to the cost of driving the particular heading as a separate entity. That is, the costs pertain only to labor and materials expended in that heading and do not include the following:

(1) Supervision costs

(2) Power costs

(3) Transportation costs to and from the heading

(4) Depreciation costs of equipment

(5) Overhead costs

It was considered that the costs listed above were too dependent upon a particular overall mining situation to be included in a valid comparison.

Summary of Direct Costs Comparisons

The results of Tables 9 (a) and (b), show that estimated costs of mining development, within the limitations described above, for the Fairbanks district vary between 95% and 130% higher than actual costs of development in Idaho in 1960. There is a close similarity between the headings compared for each area, but they are not exactly alike. A summary of the results of the comparison is given below:

Heading	Cost Per Foot: Idaho*	Cost Per Foot: Fairbanks	Fairbanks Cost x 100% / Idaho Cost
Drift, 7½' x 8', untimbered advance = 5'/shift	$15.73	$36.12	230%
Drift, 7½' x 8', untimbered advance = 6½'/shift	15.81	32.82	208%
Raise, 5' x 5½', 45* incline advance = 7½'/shift untimbered	15.30	29.79	195%

*Contract mining, subject to a maximum of 10% increase for inflation adjustment from 1960 to 1966.

The results of Tables 10 (a), (b) and 11, show that estimated costs of mining development and stoping in the Fairbanks district are from 64% to 85% higher than estimated costs for Montana in 1959. The headings compared are exactly identical in all respects. Again, the direct costs are within the limitations described above. A summary of these tables is given below:

Heading	Cost Per Foot Idaho*	Cost Per Foot Fairbanks	Fairbanks Cost x 100% / Idaho Cost
Drift, 5' x 7' (clear) timbered advance = 3'/shift	$37.89	$63.25	167%
Drift, 5' x 7', un-timbered advance = 4'/shift	24.36	41.16	169%
Raise, 7' x 7' (clear) timbered advance = 4'/shift 65° inclination	31.34	51.88	166%
Raise, 7' x 7', un-timbered advance = 6'/shift 65° inclination	17.81	29.79	167%
Chute, ore, 5' x 5' timbered advance = 4'/shift	24,58	40.32	164%
	Cost Per Ton		
Stope, cut-and-fill timbered, 21 tons (9.3 cu.yd) per shift waste fill	7.89	14.61	185%

*Subject to a maximum of 10% increase for inflation adjustment from 1960 to 1966.

TABLE 9(a). Comparison of Actual Mine Development Costs in Idaho and Estimated Costs for Fairbanks District, Alaska. (See text for limitations on costs).

OPERATIONAL PHASE	IDAHO*				FAIRBANKS			
	COST PER FOOT			PERCENT OF TOTAL	COST PER FOOT			PERCENT OF TOTAL
	LABOR	MATERIALS	TOTAL		LABOR	MATERIALS	TOTAL	
DRIFT, Untimbered, 7½' x 8', Advance = 5' Per Shift								
Drilling/Blasting	$ 3.37	$5.50	$ 8.87	56.4	$ 6.74	$10.62	$17.36	48.1
Mucking	3.11	-	3.11	19.8	6.74	-	6.74	18.7
Track	0.72	0.21	0.93	5.9	5.14	4.16	9.30	25.7
Miscellaneous	2.80	0.02	2.82	17.9	1.60	1.12	2.72	7.5
TOTAL	$10.00	$5.73	$15.73	100.0	$20.22	$15.90	$36.12	100.0
Percent of Total	63.5	36.5	100.0		56.0	44.0	100.0	
DRIFT, Untimbered, 7½' x 8', Advance = 6½' Per Shift								
Drilling/Blasting	$ 2.88	$ -	$ -		$ 5.64	$10.62	$16.26	49.5
Mucking	2.15	-	-		5.64	-	5.64	17.2
Track	0.47	-	-		4.30	4.16	8.46	25.8
Miscellaneous	2.37	-	-		1.34	1.12	2.46	7.5
TOTAL	$ 7.87	$7.64	$15.81	100.0	$16.92	$15.90	$32.82	100.0
Percent of Total	49.8	50.2	100.0		51.6	48.4	100.0	

*Actual contract costs of mining development, Idaho, 1960. _/ 2

TABLE 9(b). Comparison of Actual Mine Development Costs in Idaho and Estimated Costs for Fairbanks District, Alaska. (See text for limitations on costs).

OPERATIONAL PHASE	IDAHO* COST PER FOOT				FAIRBANKS COST PER FOOT			
	LABOR	MATERIALS	TOTAL	PERCENT OF TOTAL	LABOR	MATERIALS	TOTAL	PERCENT OF TOTAL
RAISE, 45° Inclination, 5' x 5½', Untimbered, Advance = 7½' Per Shift								
Drilling/Blasting	$4.86	-	-		$ 8.42	$10.62	$19.04	63.9
Miscellaneous	2.56	-	-		8.42	2.33	10.75	36.1
TOTAL	$7.42	$7.88	$15.30		$16.84	$12.95	$29.79	100.0
Percent of Total	48.5	51.5	100.0		56.5	43.5	100.0	

*Actual contract costs of mining development, Idaho, 1960. _/ 2

TABLE 10(a). Comparison of Estimated Direct Costs of Development Headings in Montana and Fairbanks District, Alaska. (See text for limitations on costs). _/ 3

OPERATIONAL PHASE	MONTANA COST PER FOOT LABOR	MONTANA COST PER FOOT MATERIALS	MONTANA COST PER FOOT TOTAL	MONTANA PERCENT OF TOTAL	FAIRBANKS COST PER FOOT LABOR	FAIRBANKS COST PER FOOT MATERIALS	FAIRBANKS COST PER FOOT TOTAL	FAIRBANKS PERCENT OF TOTAL
DRIFT, 5' x 7' (clear), Timbered, 30# Rail, 3' Advance Per Shift								
Timbering	$ 4.11	$ 9.42	$13.53	35.8	$ 8.42	$13.67	$22.09	34.8
Drilling/Blasting	4.11	7.90	12.01	31.7	8.42	10.62	19.04	30.0
Mucking	4.11	-	4.11	10.8	8.42	-	8.42	13.3
Track	3.11	3.41	6.52	17.2	6.42	4.16	10.58	17.0
Miscellaneous	1.00	0.72	1.72	4.5	2.00	1.12	3.12	4.9
TOTAL	$16.44	$21.45	$37.89	100.0	$33.68	$29.57	$63.25	100.0
Percent of Total	43.3	56.7	100.0		53.2	46.8	100.0	
Untimbered TOTAL	$12.33	$12.03	$24.36		$25.26	$15.90	$41.16	
Percent of Total	50.6	49.9	100.0		61.3	38.7	100.0	

TABLE 10(b). Comparison of Estimated Direct Costs of Development Headings in Montana and Fairbanks District, Alaska. (See text for limitations on costs). _/ 3

OPERATIONAL PHASE	MONTANA COST PER FOOT LABOR	MONTANA COST PER FOOT MATERIALS	MONTANA COST PER FOOT TOTAL	MONTANA PERCENT OF TOTAL	FAIRBANKS COST PER FOOT LABOR	FAIRBANKS COST PER FOOT MATERIALS	FAIRBANKS COST PER FOOT TOTAL	FAIRBANKS PERCENT OF TOTAL
RAISE, 7' x 7', Timbered, 65° Inclination, Advance = 4' Per Shift								
Timbering	$ 4.11	$ 9.42	$13.53	43.2	$ 8.42	$13.67	$22.09	42.6
Drilling/Blasting	4.11	7.90	12.01	38.3	8.42	10.62	19.04	36.7
Miscellaneous	4.11	1.69	5.80	18.5	8.42	2.33	10.75	20.7
TOTAL	$12.33	$19.01	$31.34	100.0	$25.26	$26.62	$51.88	100.0
Percent of Total	39.3	60.7	100.0		48.7	51.3	100.0	
Untimbered TOTAL	$ 8.22	$ 9.59	$17.81		$16.84	$12.95	$29.79	
Percent of Total	46.2	53.8	100.0		56.5	43.5	100.0	
CHUTE, ore, 5' x 5' (clear), Timbered, Advance = 4' Per Shift								
Timbering	$ 4.93	$ 4.54	$ 9.47	38.5	$10.11	$ 6.40	$16.51	41.0
Drilling/Blasting	4.11	7.90	12.01	48.9	8.42	10.62	19.04	47.2
Miscellaneous	1.00	2.10	3.10	12.6	2.00	2.77	4.77	11.8
TOTAL	$10.04	$14.54	$24.58	100.0	$20.53	$19.79	$40.32	100.0
Percent of Total	40.8	59.2	100.0		50.9	49.1	100.0	

TABLE 11. Comparison of Estimated Direct Costs of Stoping in Montana and Fairbanks District, Alaska. (See text for limitations on costs). _/ 3

OPERATIONAL PHASE	MONTANA				FAIRBANKS			
	COST PER TON			PERCENT	COST PER TON			PERCENT
	LABOR	MATERIALS	TOTAL	OF TOTAL	LABOR	MATERIALS	TOTAL	OF TOTAL
STOPE, Cut-and-Fill, Timbered, 21 Tons (9.32 yd^3 in Place) Per Shift, Waste Fill								
Timbering	$ 1.74	$ 1.69	$ 3.43	43.5	$ 3.56	$ 2.81	$ 6.37	45.9
Drilling/Blasting	1.74	2.12	3.86	48.9	3.56	2.82	6.36	45.9
Slusher	0.30	-	0.30	3.8	0.58	-	0.58	4.1
Fill	0.30	-	0.30	3.8	0.58	-	0.58	4.1
TOTAL	$ 4.08	$ 3.81	$ 7.89	100.0	$ 8.28	$ 5.63	$13.89	100.0
Percent of Total	51.7	48.3	100.0		59.6	40.4	100.0	

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2. Krempasky, G. T. Methods and Costs of Driving Drifts, Crosscuts and Raises in the Coeur D'Alene Mining District, Shoshone County, Idaho. U. S. Bureau of Mines Information Circular 7964. 45 pp.

3. Price, P. M. Mining Methods and Costs, Mouat Mine, American Chrome Co., Stillwater, Mont. U. S. Bureau of Mines Information Circular 8204. 1963. 58 pp.

CAPITAL EXPENDITURES

Capital investment requirements for the mining operations described in this study include the following:

(1) All mine development and construction costs from initial opening to the start of sustained production mining, including sufficient working capital to meet all obligations until mint and smelter returns begin.

(2) Mill and surface plant construction, including cost and installation of all equipment required, tune up costs and working capital as stated above.

A provision is made for initial prospecting, initial exploration, and property acquisition costs. These early costs are included in total capital investment and are to be amortized over the lives of the three mining plans discussed.

Total Investment Required for A Fifty Ton-per-Day Mine and Mill Plant

The distribution of total investment for the 50 ton-per-day operation follows, with a further breakdown shown in Tables 12 and 13 and a discussion of the other capital costs following:

Mine and mine plant........................		$ 469,734
Mill facility..............................		329,704
Other production investment		
Exploration and land acquisition costs..............	$300,000	
Heating plant..................	32,000	
Total......................	$332,000	332,000
Pre-production capital investment..........		$1,131,438
Working capital............................		193,646
Total investment required..................		$1,325,084

The total investment required includes: all costs for sufficient underground development to begin a 50 ton-per-day operation, all surface mine and mill construction (including equipment) costs for the 15 month pre-production period, and costs of sustaining operations for three months for tune up and delay in receipt of income from the mint and smelter.

Total Investment Required For A One Hundred Ton-per-Day Mine and Mill Plant

The distribution of investment funds for the 100 ton-per-day operation follows, with an additional breakdown shown in Tables 12 and 14.

Mine and mill plant		$	469,734
Mill facility			389,950
Other pre-production investment:			
Exploration and land acquisition costs	$450,000		
Heating plant	32,000		
Total	$482,000		482,000
Pre-production capital investment			$1,341,684
Working capital			338,556
Total investment required			$1,680,240

The total investment required includes: sufficient underground development costs to begin a 100 ton-per-day operation, all surface mine and mill construction costs for the 15 month pre-production period; and costs of sustaining operations for three months for tune up and delay in receipt of income from mint and smelter.

Total Investment Required For A Five Hundred Ton-per-Day Mine and Mill Plant

The distribution of investment funds required for a 500 ton-per-day operation follows with an additional breakdown shown in Tables 15 and 16.

Mine and mill plant		$ 804,675
Mill facility		1,270,900
Other pre-production investment:		
Exploration and land acquisition costs	$850,000	
Heating plant	42,000	
Total	$892,000	892,000
Pre-production capital investment		$2,967,575
Working capital		1,198,447
Total investment required		$4,166,022

The total investment required includes: all costs for sufficient underground development to begin 500 ton-per-day operation, all surface mine and mill construction (and equipment) costs for the 24 month pre-production period, and costs of sustaining operations for three months during tune up and delay in receipt of income from the mint and smelter.

Details of Capital Expenditures

It was explained in the section on The Mining Problem that the ultimate purpose of this report is to estimate the minimum grade of lode gold ore that can be mined at a suitable profit in the Fairbanks district. A general outline of the probable mining plan for an efficient operation is given in that section. However, it is necessary to be more specific in the layout of a typical 50, 100 or 500 ton-per-day operation in order to determine the probable capital investment for each case.

Mine and Mill -
50 and 100 Ton-per-Day Operations

The plan and elevation views of the hypothetical mine layout that is used as the basis for calculations of the capital expenditures for 50 and 100 ton-per-day operations are shown in Figures 12 and 13 respectively (in pocket). Both operations would be identical except for the number of shifts worked and the sizes of some of the mill equipment. Within the limits of practicality, the pre-production expenses for the mine would be the same.

In addition to the basic assumptions indicated in the section on The Mining Problem, there are several other factors that have been assumed in the layout and subsequent calculations:

(1) The property is wholly owned by the operator; that is, no royalties or lease payments are to be paid.

(2) 40% of the levels require timbering

(3) The inclined raise requires timbering

(4) The ore chutes require timbering, but the waste chutes do not

(5) Other than for assays and mill tests, no substantial amount of ore are removed from the mine before full scale production. That is, no income is derived from ore during the pre-production development period.

(6) Surface buildings, including the mill and mine plant structures, are heated by steam from coal fired furnaces

(7) Mining will progress above the main haulage level, to take full advantage of gravity, until the time when profits from mining lower levels become competitive with this system. This may be due to ore grade variance or increased operating costs from extensive lateral transportation.

(8) The main haulage level is situated near the foot of moderate relief, allowing just enough relief below it for the mill to take advantage of gravity-flow systems.

(9) Capital expenses for a hoisting system must be assumed at a later period during the mine operation when it is necessary to mine below the main haulage level. They are not considered here.

(10) The underground workings are developed to the extent that full tonnage output may be immediately assumed after the pre-production period.

(11) The period of pre-production development is estimated to be 15 months.

A summary of estimated pre-production development and mine plant costs for the 50 and 100 ton-per-day operations are presented in Table 12. The terms used for mine costs are explained as follows:

(1) Contract Services Costs - payments made to contractors for services rendered such as transporting equipment and materials from Fairbanks to the mine site, or for building and electrical construction work.

(2) Mine Labor Costs - payments for wages and other costs of labor for company-hired personnel for their services such as underground development, surface track laying, or supervision.

(3) Capital Equipment Costs - Non-expendable equipment costs are payable for equipment with resale value which are not direct costs to any particular location in the mine. Expendable equipment costs are payable toward items that have little or no resale value and that are usually considered as direct costs to a specific mine location. These include the costs of explosives and drill bits.

(4) Overhead Costs - the cost of heat, electricity, and other miscellaneous items such as insurance.

A summary of the capital expenditures estimated for a 50 ton-per-day mill is given in Table 13, and for a 100 ton-per-day mill in Table 14. The cost items are self-explanatory. Detailed itemized descriptions and costs of mine and mill equipment is presented in Appendix III and IV.

Mine and Mill - Five Hundred Ton-per-Day Operation

The layout for pre-production development of this size operation is not given for the sake of eliminating repetition. The differences from the 50 or 100 ton-per-day development layout can be simply stated:

(1) Eight stopes must be initially developed instead of three.

(2) The mill is considerably larger, and its flow sheet is given in the section on The Milling Problem.

(3) The mine plant buildings may be somewhat larger, but the same number and types are required.

The assumptions given in the preceding sub-section are also valid for the 500 ton-per-day operation. A summary of estimated pre-production development and mine plant costs are given in Table 15. The pre-production development period is estimated to be 24 months. Estimated capital costs for the mill are presented in Table 16. Detailed itemized description and costs of mine and mill equipment is given in Appendix V.

TABLE 12. Summary of Estimated Costs for Pre-Production Development and Mine Plant for 50 and 100 Ton-per-Day Lode Mining Operations, Fairbanks District, Alaska.

	COSTS		
ITEM	SURFACE PLANT	UNDERGROUND	TOTAL
Contract Services	$ 52,912	$ 3,000	$ 55,912
Mine Labor	27,115	146,130	173,245
Capital Equipment			
Non-expendable	77,932	104,975	182,907
Expendable	10,340	31,745	42,085
Overhead	3,485	12,100	15,585
TOTAL	$171,784	$297,950	$469,734

Period of Pre-production Development = 15 months

TABLE 13. Summary of Estimated Costs for Erected 50 Ton-per-Day Gold Mill, Fairbanks District, Alaska.

ITEM		COST
Site Preparation		$ 10,660
Buildings (erected)		130,000
Machinery and Equipment		
f.o.b. Fairbanks	$83,195	
Installation	12,860	
Transportation (Fairbanks - mill site)	600	
		96,655
Electrical, excluding motors		25,000
Painting		2,575
Field construction expense (field supervision, clerical, warehousing, insurance, payroll taxes, recruiting costs, miscellaneous supplies)		19,290
Maintenance equipment		2,890
Spares		8,320
Miscellaneous plant items		775
Plant design, erection supervision, start-up		19,025
TOTAL CONSTRUCTION COSTS		$315,190
Project management and miscellaneous overhead cost		11,574
Transaction, use, sales, and miscellaneous local taxes		2,940
TOTAL ERECTED MILL COST		$329,704

TABLE 14. Summary of Estimated Costs for Erected 100 Ton-per-Day Gold Mill, Fairbanks District, Alaska.

ITEM		COST
Site preparation, excavation and earthwork		$ 12,435
Buildings (erected)		160,000
Machinery and equipment		
f.o.b. Fairbanks	$92,765	
Installation	15,000	
Transportation (Fairbanks - mill site)	700	
		108,465
Electrical, excluding motors		30,000
Painting		3,000
Field construction expense (field supervision, clerical, warehousing, insurance, payroll taxes, recruiting costs, miscellaneous supplies)		22,500
Maintenance equipment		3,375
Spares		9,275
Miscellaneous plant items		900
Plant design, erection supervision, start-up		22,500
TOTAL CONSTRUCTION COSTS		$372,450
Project management and miscellaneous overhead cost		14,000
Transaction, use, sales, and miscellaneous local taxes		3,500
TOTAL ERECTED MILL COST		$389,950

TABLE 15. Summary of Estimated Costs for Pre-production Development and Mine Plant for 500 Ton-per-Day Lode Mining Operation, Fairbanks District, Alaska.

	COSTS		
ITEM	SURFACE PLANT	UNDERGROUND	TOTAL
Contract Services	$ 85,240	$ 5,000	$ 90,240
Mine Labor	33,715	292,880	326,595
Capital Equipment			
Non-expendable	123,015	164,930	287,945
Expendable	12,380	56,970	69,350
Overhead	3,695	26,850	30,545
TOTAL	$258,045	$546,630	$804,675

Period of Pre-production Development = 24 months

TABLE 16. Summary of Estimated Costs for Erected 500 Ton-per-Day Gold Mill, Fairbanks District, Alaska.

ITEM		COST
Site Preparation, excavation and earthwork......$		54,520
Buildings..		379,000
Machinery and equipment		
f.o.b. Fairbanks.................	$346,600	
Installation.....................	66,080	
Transportation (Fairbanks - mill site).....................	2,000	
		414,680
Electrical, excluding motors.....................		150,000
Painting...		13,220
Field construction expense (field supervision, clerical, warehousing, insurance, payroll taxes, recruiting costs, miscellaneous supplies).................................		75,000
Maintenance equipment............................		14,870
Spares...		34,650
Miscellaneous plant items........................		3,960
Plant design, erection supervision, start-up....		75,000
TOTAL CONSTRUCTION COSTS.........................		$1,214,900
Project Management and Miscellaneous Overhead Cost.............................		50,000
Transaction, use, sales, and miscellaneous local taxes............................		6,000
TOTAL ERECTED MILL COST..........................		$1,270,900

Miscellaneous Items - All Operations

The following capital investment items are treated separately from the mine or mill since amortization charges for the items will be treated as an overhead or fixed cost for the purposes of this study.

Cost of Heating Plant

The heating plant was treated separately for amortization purposes as it is a unit not directly a part of the mine or mill. The total capital cost of the heating plant and system as estimated for each operation is as follows:

Operation	Capital Cost of Heating Plant and System
50 TPD	$32,000
100 TPD	32,000
500 TPD	42,000

Cost of Land Acquisition and Surface Exploration

In order to arrive at a final figure for minimum value of ore that could be mined at a profit, it was necessary to assume expenses for land acquisition and surface exploration. The following values were selected:

Operation	Land Acquisition	Surface Exploration	Total
50 TPD	$100,000	$200,000	$300,000
100 TPD	200,000	250,000	450,000
500 TPD	500,000	350,000	850,000

Amount of Working Capital

It is necessary to have working capital available to pay labor, material, power, and other miscellaneous expenses during the period when the mine just begins production but smelter and mint returns have not yet come in. The following sums were assumed to be available (and amortized) for this purpose on the basis of three months expenses:

Operation	Working Capital
50 TPD	$ 193,646
100 TPD	338,556
500 TPD	1,198,447

FINANCING

The success of any business venture depends upon many variables, including adequate financing. Historically a major contributing factor listed as a cause of business failure is lack of operating funds. Capital intensive industry (like mining) is especially vulnerable to being caught, during minor emergencies, with insufficient funds with which to carry on operations.

The nature of underground mining requires that conscientious financial planning must accompany the other phases of planning if the project is to be a success. Money must be available at the right time and in proper amounts to carry on development and mining operations in the most efficient manner which can be devised. In this event unforseeable problems arise (such as underground opening support, flooding, or labor productivity problems) prearranged sources of new funds must be available to guarantee continuous operations, and to permit changes in the operating plan.

It is the purpose of this section to investigate sources and costs of funding for Fairbanks district lode gold mining. For investigation purposes, the funds required were separated into two types: (1) initial capital investment, and (2) operating funds.

Sources of Funds for Initial Capital Investment

Investment in a mining property can be considered to begin with prospecting and exploration. Funds expended for prospecting may be expensed or "written off" for income tax purposes in the year in which they were incurred or be included in revised tax carry back or forward provisions. In the case of newly-formed business concerns, prospecting costs can be carried forward for income tax purposes, as expenses against future income for five years.

Actual capital improvements to a mining property (including all pre-production expense) are permitted to be amortized or depreciated against gross income for tax purposes for specific facility or equipment lives, less salvage value. Again, carry-forward provisions apply.

Since new mines are almost always begun under the corporate form of business, (due chiefly to access to money sources) it is assumed that the mining plants studied here are corporate-owned. As such two cases were considered - one being a newly formed Alaska corporation and the other a mature outside or foreign corporation.

Capital funds for investment in new mining ventures is virtually non-existant in the interior. When questioned about raising the moderate sum of $1,000,000 of capital funds through the formation of a corporation (under Alaska Statutes Title 10, Chapter 05 and Title 45, Chapter 55) for mining, two local banks and their legal counsels replied negatively. Answers to the above question regarding underground <u>gold</u> mining were emphatically <u>NO</u>, with comments such as: "Everyone knows that gold mining won't pay," and "The public won't put one dime in Alaska gold mining securities - gold has too low a price." _/ 1

Hence, despite a legal framework for forming corporations, (since statehood and the adoption of the above laws, Alaska is no longer a "blue sky" investment climate) little if any success can be expected in raising sufficient mining funds through the sale of securities in Alaska.

Established mining corporations with sources of venture capital outside of Alaska will be required to prospect, develop, and establish the mining plants described in this report.

However, a limited approach to mine development lies in governmental sources of initial capital funds for prospecting. The Alaska State Prospectors' Aid Program (Alaska Statutes, Title 11, Chapter 5) may be considered as a primary step. Also of importance is the program of the United States Department of Interiors' Office of Mineral Exploration (OME) for which mining entrepreneurs and companies may qualify. _/ 2 Funds from this source effectively extend the applicants' financial resources, (to 50% of a planned project to a maximum of $250,000) but some financial capability must exist originally.

If a prospect thus found and explored qualifies, a source of development money lies in the United States Small Business Administration (Also at this stage the property may be salable outright or on a percentage participation basis to an outside mining corporation). However, their limited use points up the rather large amount of money which must be spent on a prospect to actually outline measured ore. In other words, prospectors and developers usually exhaust their sources of funds before the ore occurrence is fully explored, or else the property proves to be a blank. (In general if a truly worthwhile ore body is located with personal, state, and OME funds it invariably is developed with corporate funds). Gold mining possibilities simply do not attract the prospector and mining entrepreneur as they once did, owing to the low market value of gold.

The conclusion regarding availability of initial capital funds for lode gold mining in Alaska is a bleak one. The Fairbanks market place of mining finance displays low esteem for gold ventures.

Sources of Operating Funds

In spite of the dismal picture for local capital investment availability, the question of local sources for operating funds was raised. Two Fairbanks banks were questioned, and both had maximum loaning capacity of about $100,000 each (due to National Bank Regulations to any single borrower). "Participation" loans, where Anchorage or possibly Seattle banks would join in a loan project, can be obtained. These regular business loans must be backed by adequate assets and require 8% simple interest. The bankers personally contacted stated that mining bears no special hardship, but gold mining, due to experience since World War II, is highly suspect as a worthy investment for even short term loans, and would depend mainly on the financial stature of the loan applicant.

Summary

Sources of funds for finding and developing underground gold mines do not exist in Interior Alaska. Some assistance may be obtained from State Prospectors' Aid Program, the United States Office of Mineral Exploration, and Small Business Administration, but the applicant must have funds or assets to begin with. From a financial viewpoint, underground mining and especially underground gold mining, is considered extremely speculative at best.

REFERENCES

1. Private communication, President, First National Bank of Fairbanks, and Executive Vice President, Alaska National Bank of Fairbanks, to D. W. Huber, February 9, 1967.

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MINIMUM VALUES AND TONNAGES

The ultimate objective of this report is to determine the minimum value of lode gold ore that can be mined at a profit in the Fairbanks district, Alaska, for each of a 50, 100, and 500 ton-per-day operation. The previous sections of this report have described the factors that affect the elemental costs. This section gives the results of an engineering estimate of the total costs of operation by incorporation of these elemental costs into typical assumed mining and milling conditions. The final results of the estimate and the corresponding minimum values of ore that can be mined are given below:

	50 TPD	100 TPD	500 TPD
Minimum Value of Ore, $/ton	$ 75.637	$ 61.977	$ 40.980
Assumed Profit, $/ton	$ 7.775	$ 4.918	$ 2.940
Total Capital Investment	$1,325,084	$1,680,240	$4,178,402
Assumed Profit, % of Capital Investment Per Year	10.87%	10.54%	12.16%
Assumed Ore Reserve, Tons	92,610	180,075	2,074,464
Assumed Ore Reserve, Years	5	5	12

The mining system used as basis of the estimate is outlined in the section on The Mining Problem. The general assumptions that are necessary for ground-rules for the estimate are also stated in that section.

The milling system and flow sheets that are assumed as typical are given in the section on The Milling Problem. The expected capital expenditures for both the mine and mill, along with the assumed plant layout that would envelop these costs, are given in the section on Capital Expenditures.

Various elements of operating costs, including labor costs, materials costs, transportation costs, power costs, and taxes are given in the section on Operating Costs. These cost elements are the basis of estimation for the actual operating costs of the 50, 100, and 500 ton-per-day operations.

A summary of the estimated mine expense is given in Table 17, of this section; a summary of estimated mill expense is given in Table 18. Miscellaneous expenses, attributable to neither the mill or mine alone, are summarized in Table 19. A summary, more complete than that above, of the calculations for estimating minimum values is shown in Table 20.

The following descriptions of the items in these cost summaries will assist the reader in interpreting the limitations of each item.

Personnel Costs

Labor

The total cost of labor includes wages, payroll taxes borne by the employer, and all other forms of compensation and fringe benefits. These costs are summarized according to craft in the section on Operating Costs. An assumed distribution of labor, used as basis for estimation of costs, is given in Appendix VIII. Assumptions of the number of shifts-per-week, shifts-per-year, and other pertinent factors are given in Appendix VI and VII.

TABLE 17. Summary of Costs of Operation for the Mine

ITEM	50 TPD		100 TPD		500 TPD	
	$/TON	$/YEAR	$/TON	$/YEAR	$/TON	$/YEAR
Labor	$16.867	$312,411	$17.124	$ 616,721	$13.407	$2,317.695
Staff	4.431	82,071	2.862	103,075	1.780	307,712
SUBTOTAL, Personnel	$21.298	$394,482	$19.986	$ 719,796	$15.187	$2,625,407
Development Materials and Supplies	$ 2.182	40,415	2.073	74,659	1.855	320,678
Stoping Materials and Supplies	5.660	104,835	5.377	193,653	4.811	831,687
Miscellaneous Materials and Supplies	0.777	14,392	0.738	26,579	0.660	114,096
SUBTOTAL, Materials and Supplies	$ 8.619	$159,642	$ 8.188	$ 294,891	$ 7.326	$1,266,461
Power	$ 1.159	$ 21,467	$ 1.129	$ 40,661	$ 0.507	$ 87,646
Amortization, Pre-production Expenditures (mine only)	5.072	93,944	2.609	93,963	0.394	68,112
Taxes, sales	0.431	7,983	0.245	8,824	0.110	19,016
TOTAL COSTS OF OPERATION OF MINE	$36.579	$677,518	$32.157	$1,158,135	$23.524	$4,066,642

TABLE 18. Summary of Costs of Operation on Mill

ITEM	50 TPD		100 TPD		500 TPD	
	$/TON	$/YEAR	$/TON	$/YEAR	$/TON	$/YEAR
Labor	$ 5.426	$100,500	$ 3.980	$143,340	$2.021	$ 349,374
Staff	0.902	16,707	0.937	33,746	0.493	85,226
SUBTOTAL, Personnel	$ 6.328	$117,207	$ 4.917	$177,086	$2.514	$ 434,600
Materials and Supplies	$ 3.843	$ 71,180	$ 3.193	$114,996	$2.074	$ 358,537
Power	0.839	15,540	0.632	22,761	0.560	96,808
Amortization, Pre-production Expenditure (mill only)	3.560	65,938	2.165	77,972	0.613	105,971
Taxes, sales	0.192	3,557	0.095	3,421	0.030	5,186
TOTAL COSTS OF OPERATION OF MILL	$14.762	$273,422	$11.002	$396,236	$5.791	$1,001,102

TABLE 19. Summary of Costs of Operation for Entire Plant

ITEM	50 TPD		100 TPD		500 TPD	
	$/TON	$/YEAR	$/TON	$/YEAR	$/TON	$/YEAR
Heating Plant	$ 0.345	$ 6,390	$ 0.177	$ 6,375	$ 0.020	$ 3,457
Land Acquisition and Exploration	3.239	59,993	2.490	89,677	0.410	70,878
Working Capital	2.091	38,730	1.880	67,708	0.578	99,920
SUBTOTAL, Amortization	$ 5.675	$ 105,113	$ 4.547	$ 163,760	$ 1.008	$ 174,255
Taxes, Property	$ 0.065	$ 1,200	$ 0.067	$ 2,400	$ 0.028	$ 4,800
Miscellaneous Costs	- 1.164	21,560	1.106	39,833	0.989	170,970
TOTAL MISCELLANEOUS COSTS OF OPERATION	$ 6.904	$ 127,873	$ 5.720	$ 205,993	$ 2.025	$ 350,025
Total Mine and Mill Costs of Operation Brought Forward	$51.341	$ 950,940	$43.159	$1,554,371	$29.315	$5,067,744
SUBTOTAL, COSTS OF OPERATION	$58.245	$1,078,813	$48.879	$1,760,364	$31.340	$5,417,769
Contingency, 5% of Subtotal	$ 2.912	53,941	2.444	88,018	1.567	270,888
TOTAL COSTS OF OPERATION OF ENTIRE PLANT	$61.157	$1,132,754	$51.323	$1,848,382	$32.907	$5,688,657

Staff

The total cost of staff (supervision, engineering, and engineering technician) includes salaries, payroll taxes borne by the employer, and all other fringe benefits. These costs are summarized in the section on Operating Costs. An assumed staff complement is outlined in Appendix IX, and the total costs calculated from this basis. Other necessary assumptions are listed in Appendix VI and VII.

Materials and Supplies

The cost of materials and supplies were estimated from assumed usage of various expendable items. These items include fuel, tools, repair parts, explosives, timber, and all other supplies required for operation of the mine and mill. In Table 17 these costs for the mine have been categorized into development, stoping, and miscellaneous expenses. In Appendix X these costs have been categorized into each operational phase of the mine and mill. These costs all include transportation costs to the plant site, but they are exclusive of sales tax.

Power

The cost of electrical power was calculated from estimated values of energy consumption and maximum demand in conjunction with unit costs provided by Schedule No. 16 of the Golden Valley Electric Association. The cost of power for the mine and mill was calculated separately, assuming a separate meter for each. Power costs for surface buildings other than the mill are included in the total for the mine, as it is the major user.

Amortization of Pre-Production Expenses

All costs of plant preparation and development prior to production including labor, contract services, capital equipment, expendable materials and supplies, power, and taxes, were amortized over the expected life of the operation. The assumed reserves and operating life for each operation have previously been given in this section.

These pre-production costs do not include the expenses due to installation of the heating plant, land acquisition, surface exploration, working capital, and other miscellaneous costs not directly attributable to either the mine or mill. Further discussion on amortization and depreciation is given in the section on Capital Expenditure. Costs of capital equipment for the mine and mill are detailed in Appendix III, IV, and V. Selection of these items is based on the operations as described in the sections on The Mining Problem and The Milling Problem. The periods of pre-development and preparation are given for each operation in Appendix VI.

Sales Taxes

It was assumed that a certain percentage of total purchases of supplies and materials would be obtained in the City of Fairbanks for the purpose of estimating sales tax. The percentage of purchases varied with the size of the operation because of the possibility of large-lot buying direct from manufacturers. The assumptions are as follows:

Operation	Percent of Purchases Made in Fairbanks
50 TPD	100%
100 TPD	60%
500 TPD	30%

Amortization of Heating Plant, Land Acquisition, Surface Exploration, and Working Capital

The total costs of the heating plant, land acquisition, surface exploration, and working capital (as assumed) is given in the section on Capital Expenditure. These costs were amortized on a straight-line basis according to the expected life of each operation.

Property Taxes

The average Fairbanks-North Star Borough property tax in the mining areas of the Fairbanks district appears to be approximately $200 per patented claim. _/ 1 For the purpose of this report, the following property sizes and corresponding property taxes per year were assumed:

Operation	Number of Claims	Annual Property Tax
50 TPD	6	$1,200
100 TPD	12	2,400
500 TPD	24	4,800

Miscellaneous Costs

Miscellaneous costs include those costs of operation which are not directly attributable to either the mine or mill, but are charged against the operation as a whole. These costs include the cost of coal for heating, accounting fees, legal advice, and other various overhead items.

Contingency

Because of the indefinite occurrence of some problems, such as labor strikes, stope failures, and other production delays, a contingency of 5% of the total operating costs was added to the subtotal.

Smelter Charges and Transportation Costs for Concentrates

It is necessary to estimate a reasonable smelter charge and transportation cost for concentrates even though the specific value of the concentrates is unknown. For the purpose of this estimate the following assumptions were made:

(1) Two per cent of the total ore tonnage is gold bearing sulphides

(2) Payment is made for gold alone

(3) Ten per cent of the value of the ore is recovered in the concentrates (85% was recovered by amalgamation, and 5% is tails)

(4) The total value of the ore is approximately $100 per ton

These assumptions are made for this estimate alone, and they do not presuppose a conclusion to the problem of minimum value. The smelter charges and transportation costs will vary with grade of the concentrate, but it is necessary to include a reasonable estimated expense for these items in the final cost summary.

Operation	Transportation and Handling Charges From Mill Site to Smelter	Smelter Charges	Total
50 TPD	$ 30,309/yr.	$ 17,020/yr.	$ 47,329/yr.
100 TPD	58,882/yr.	33,102/yr.	92,002/yr.
500 TPD	282,795/yr.	159,068/yr.	441,863/yr.

Mint Charges

Mint charges must be estimated for similar reasons as the smelter charges. The following assumptions were made for this estimation:

(1) The gold is 850 fine

(2) Eighty-five per cent of the total value of the ore is recovered in the free state by amalgamation.

(3) The total value of the ore is approximately $100 per ton

On the basis of these assumptions, mint charges and mailing expense total $0.498 per ounce.

Required Profit

There are many ways in which to treat the cash flow from a mining operation and the consequent return to its owners. In view of this fact the following assumptions are made for the purpose of estimating a required profit for this report:

(1) The organization of ownership is a corporation, which was formed only for the exploitation of this particular mining property. The organization is to be disbanded upon depletion of the ore reserves.

(2) The principal of the capital investment plus 10% interest (compounded annually) is to be returned to ownership upon depletion of the ore reserves.

(3) Funds received annually from amortization of the capital investment are to be set aside in a sinking fund to gain interest at the rate of 6% per annum (compounded annually) until the ore reserves are depleted. At the

end of the life of the mine, therefore, this sinking fund will accumulate the initial capital investment plus a certain amount of interest.

(4) The profit that must be obtained from the operation is therefore the difference between the expected return, after expenses and taxes, to the corporation and the sum that is accumulated by the sinking fund.

(5) This profit, however, may be partially derived from depletion allowances, as the assumed circumstances do not prescribe other uses for the funds from this allowance.

On the basis of the above assumptions, the annual sum of depletion plus net income after taxes must be:

Operation	Depletion Plus Net Income After Taxes
50 TPD	$144,000
100 TPD	177,105
500 TPD	508,187

Minimum Values

The summation of all known expenses, excluding profit, will give total operating costs. An algebraic solution for the sum of depletion plus net income after taxes can be made in terms of the unknown value of gross returns. The sum of depletion plus net income after taxes is known from the value of profit required by the operation, therefore, the gross returns necessary to provide this can be solved. Because this cash flow is the minimum, the gross returns will be the minimum that will sustain the mining operation under the assumed conditions. The elements of the above calculations are shown in Table 20.

TABLE 20. Summary of Calculations for Minimum Value of Ore

ITEM	50 TPD		100 TPD		500 TPD	
	$/TON	$/YEAR	$/TON	$/YEAR	$/TON	$/YEAR
Total Costs of Operation						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Summary

Comparisons involving the minimum values and tonnages as estimated in this report should be made with caution. The operating costs have been prepared in enough detail to be considered accurate for this particular situation of mining and milling. The costs of capital equipment and construction have also been estimated with equal accuracy. However, assumed costs, such as the cost of land acquisition, surface exploration, smelter charges, mint payment losses, and borrowing money, have been illustrated by reasonable values only, which, in the real instance, may vary considerably. It was necessary to make these assumptions of costs and reserves to arrive at a final minimum value of grade.

Dilution has not been considered. Therefore, comparisons of grade values should be made on the basis of mill heads only.

REFERENCES

1. Fairbanks-North Star Borough. Personal Communication. 1967.

APPENDIX I

DIRECT COSTS OF LABOR PER SHIFT

Specific Type of Labor	Straight Time Wages Per Shift	*Premium Wages Per Shift	**Vacation Pay Per Shift	Total Wages Per Shift
Miner	$40.20	$3.35	$1.34	$44.89
Miner's Helper	36.60	3.05	1.22	40.87
Timberman	36.60	3.05	1.22	40.87
Motorman	36.60	3.05	1.22	40.87
Hoistman	40.20	3.35	1.34	44.89
Skiptender	36.60	3.05	1.22	40.87
Nipper	36.60	3.05	1.22	40.87
Surfaceman	33.00	2.75	1.10	36.85
Blacksmith	36.60	3.05	1.22	40.87
Carpenter	36.60	3.05	1.22	40.87
Electrician	36.60	3.05	1.22	40.87
Machinist	36.60	3.05	1.22	40.87
Maintenanceman	36.60	3.05	1.22	40.87
Mechanic	36.60	3.05	1.22	40.87
Mechanic's Helper	34.60	2.88	1.15	38.63
Lampman	34.60	2.88	1.15	38.63
Truckdriver	34.60	2.88	1.15	38.63
Payroll Clerk	34.10	2.84	1.14	38.08
Clerk	27.25	2.27	0.91	30.43
Millman	36.60	3.05	1.22	40.87

*Based upon a 6 day work-week and prorated per shift.

**Based upon a 10-shift vacation and prorated per shift. This is an average figure which includes paid holidays and considering that some labor would be ineligible for vacation.

APPENDIX I (Continued)

Specific Type of Labor	*FICA Per Shift	**State Unemployment Insurance Premium	Hospital Medical Premium	***Retiremer Plan Per Shi
Miner	$0.91	$0.70	$0.60	$0.60
Miner's Helper	0.91	0.70	0.60	0.60
Timberman	0.91	0.70	0.60	0.60
Motorman	0.91	0.70	0.60	0.60
Hoistman	0.91	0.70	0.60	0.60
Skiptender	0.91	0.70	0.60	0.60
Nipper	0.91	0.70	0.60	0.60
Surfaceman	0.91	0.70	0.60	0.60
Blacksmith	0.91	0.70	0.60	0.60
Carpenter	0.91	0.70	0.60	0.60
Electrician	0.91	0.70	0.60	0.60
Machinist	0.91	0.70	0.60	0.60
Maintenanceman	0.91	0.70	0.60	0.60
Mechanic	0.91	0.70	0.60	0.60
Mechanic's Helper	0.91	0.70	0.60	0.60
Lampman	0.91	0.70	0.60	0.60
Truckdriver	0.91	0.70	0.60	0.60
Payroll Clerk	0.91	0.70	0.60	0.60
Clerk	0.91	0.70	0.60	0.60
Millman	0.91	0.70	0.60	0.60

*Based upon 300 working shifts per year and a maximum of $2 contribution.

**Based upon 2.9% standard rate for the first $7200 in wages 300 working shifts per year. The credit for this premium against Federal Unemployment Tax leaves only $12 per year employee to be paid as F.U.T. This amount on a per-shift is superfluous.

***Based upon 3 tons per manshift and $0.20 per ton.

APPENDIX I (Continued)

Specific Type of Labor	Afternoon Shift Differential	Total Direct Labor Cost on Afternoon Shift/Shift	Night Shift Differential
Miner	$0.80	$53.56	$1.20
Miner's Helper	0.80	49.09	1.20
Timberman	0.80	49.09	1.20
Motorman	0.80	49.09	1.20
Hoistman	0.80	53.56	1.20
Skiptender	0.80	49.09	1.20
Nipper	0.80	49.09	1.20
Surfaceman	0.80	41.83	1.20
Blacksmith	0.80	46.00	1.20
Carpenter	0.80	46.00	1.20
Electrician	0.80	49.09	1.20
Machinist	0.80	46.00	1.20
Maintenanceman	0.80	49.09	1.20
Mechanic	0.80	49.49	1.20
Mechanic's Helper	0.80	46.60	1.20
Lampman	0.80	43.68	1.20
Truckdriver	0.80	43.68	1.20
Payroll Clerk	0.80	43.11	1.20
Clerk	0.80	35.18	1.20
Millman	0.80	46.64	1.20

APPENDIX II

COSTS OF MATERIALS AND SUPPLIES

Category	Item	Description	Unit Cost f.o.b. Fairbanks
Petroleum Products	Fuel, diesel, #2	For internal combustion engines; over 500 gallons per bulk shipment.	$ 0.328/gal.
		For heat	0.248/gal.
	Gasoline, regular	For bulk shipments of over 400 gallons	0.394/gal.
	Gasoline, premium	For bulk shipments of over 400 gallons	0.434/gal.
	Grease, S.A.E. 90	35-pound buckets	7.97/bucket
	Grease, S.A.E. 140	35-pound buckets	7.97/bucket
	Oil, compressor, S.A.E. 5	5-gallon bucket	5.86/bucket
	Oil, compressor, S.A.E. 9	5-gallon bucket	6.06/bucket
	Oil, cutting	5-gallon bucket	6.06/bucket
	Oil, lubricating all S.A.E.	55-gallon drum	1.37/gal.
	Oil, rock drill	55-gallon drum	1.11/gal.
	Oil, stove	For heat; over 500 gallons per bulk shipment	0.26/gal.
	Preservative, wood	55-gallon drum	1.26/gal.
Coal and Propane	Coal, lump nut	At the bunker	15.40/ton
	Coal, stoking	At the bunker	13.85/ton
	Coal, blacksmith	100-pound sacks	10.00/sack
	Propane, bottled	100-pound bottles	14.00/bottle
	Propane, bulk	Bulk shipments of 1000 gallons; supplier provides storage container.	4.23/gal.
Building Products	Cement, portland	94-pound sack	3.85/sack
	Door, storm	30' x 79', veneer	32.50/each
	Guttering, galvanized	28 guage	0.44/ft.
	Insulation, fiberglass	2 in. thick	5.80/100 ft^2
	" "	3 in. thick	7.80/100 ft^2
	" "	6 in. thick	13.00/100 ft^2
	" "	Bulk	0.15/lb.
	Paint, oil base	Gallon cans	9.65/gal.
	Plywood, exterior	B.C. fir, 3 ply	31.30/100 ft^2
		" 5 ply	51.72/100 ft^2
	Plywood, interior	B.C. fir, 3 ply	23.70/100 ft^2
		" 5 ply	35.20/100 ft^2
	Roofing, asphalt	Bundle for 100-foot coverage	10.00/bundle

APPENDIX II (Continued)

Category	Item	Description	Unit Cost f.o.b. Fairbanks
Building Products (Continued)	Sand, concrete	At the plant	$ 5.00/ton
	Sand, mortar	At the plant	6.50/ton
	Shingles, asphalt	Bundle for 100-foot coverage	23.25/bundle
	Siding, asphalt	Bundle for 100-foot coverage	10.00/bundle
	Timber, rough	Spruce	145.00/1000 bd.ft.
Miscellaneous Hardware and Tools	Acetylene, bottled	244 cu. ft. bottles	35.00/bottle
	Bars, wedge point	6-foot, steel	10.15/each
	Bits, drill, carbide	Threaded, 7/8"ID, 1½" OD	15.50/each
	"	Threaded, 7/8"ID, 1-5/8" OD	16.05/each
	"	Threaded, 7/8"ID, 2" OD	18.85/each
	Bits, drill, steel	Threaded, 7/8"ID, 1-3/8" OD	1.24/each
	"	Threaded, 7/8"ID, 1-5/8" OD	1.26/each
	"	Threaded, 7/8"ID, 2" OD	1.34/each
	Boots, Hard toe		15.00/pair
	Come-alongs	1½-ton capacity	71.50/each
	Connections, Air hose	Dixon couplings with clamp	1.85/each
	Connections, water hose	"	1.85/each
	Hammer, 4-pound		5.15/each
	Hammer, 10-pound		10.95/each
	Hats, hard		10.00/each
	Hoists, chain, manual	1-ton capacity	45.90/each
	Hose, air	1-inch ID	1.15/ft.
	Hose, water	3/8" ID	0.32/ft.
	Jack, hydraulic	20-ton capacity	47.00/each
	Kit, first aid	Emergency	8.50/each
	"	General	16.95/each
	"	Industrial	33.00/each
	Level, carpenter	3-foot long	10.45/each
	Nails	50d	0.24/lb.
	Oxygen, bottled	244 cu. ft. bottles	14.64/bottle
	Picks	Double-pointed	6.85/each
	Rope, wire	6 x 19 Regular Lay, ¼"	0.18/ft.
	"	6 x 19 Regular Lay, 3/8"	0.25/ft.
	"	6 x 19 Regular Lay, ½"	0.29/ft.
	"	6 x 19 Regular Lay, 5/8"	0.36/ft.
	Shovel, #2	Short handle	5.85/each
		Long handle	5.60/each

APPENDIX II (Continued)

Category	Item	Description	Unit Cost f.o.b. Fairbanks
Foodstuffs (Continued)	Miscellaneous: (Continued)	Butter	$ 0.89/lb.
		Cheese	0.86/lb.
		Coffee	0.80/lb.
		Corn flakes	0.49/lb.
		Eggs	0.89/doz.
		Flour	0.19/lb.
		Ice cream	1.29/½ gal.
		Margarine	0.41/lb.
		Milk	0.93/½ gal.
		Rice	0.42/lb.
		Sugar	0.20/lb.
		Tea, bags, 48	0.87/pkg.
Track Materials	Benders, track	30# rail	70.00/each
	"	45# rail	85.00/each
	Belts, track	30# rail, 200# keg	50.00/keg
	"	45# rail, 200# keg	45.00/keg
	Jacks, track, rachet type	10 Ton	60.00/each
	"	20 Ton	90.00/each
	Mauls, spike		10.00/each
	Plates, splice	30# rail	1.38/pair
	"	45# rail	2.27/pair
	Pullers, spike		18.00/each
	Rail, 30 ft. lengths	30#	1.32/ft.
	"	45#	2.03/ft.
	Spikes, track, 30# rail	200# keg	34.50/keg
	" 45# rail	200# keg	33.00/keg
	Turnouts, 30# rail, complete with switchstand		280.00/each
	Turnouts, 45# rail, complete with switchstand		300.00/each
Ventilation Materials	Couplings, vent tubing		3.00-5.00/each
	Tubing, vent flexible (50 ft. lengths with sewed-in couplings)	8" dia.	75.00/each
	"	12" dia.	95.00/each
	"	16" dia.	105.00/each
	"	20" dia.	135.00/each
	"	24" dia.	165.00/each

APPENDIX II (Continued)

Category	Item	Description	Unit Cost f.o.b. Fairbanks
Miscellaneous Mill Supplies	Aerofloat 238		$ 0.32/lb.
	Bags, concentrate		
	Balls, grinding		
	Boards, pallet		
	Copper sulphate		0.19/lb.
	Dow froth		0.32/lb.
	Isobutyl carbonol frother		0.23/lb.
	Lime		0.06/lb.
	Mercury		
	Pine oil		0.20/lb.
	Sodium cyanide		0.27/lb.
	Xanthate Z-6		0.38/lb.
	Xanthate Z-11		0.33/lb.
	Zinc sulphate		0.13/lb.

APPENDIX III

DETAILED DESCRIPTIONS AND COSTS OF MINE AND MILL EQUIPMENT FOR FIFTY TON-PER-DAY LODE GOLD OPERATION

I. Mine

Item Description	Quantity	Total HP	Total Weight (#
Block, dump, retractable, Grancy type	1	-	-
Blocks, slusher	10	-	-
Breaker, paving	1	-	60
Buildings, Miscellaneous	6	-	-
Car, muck, Granby type, 90 CFT, 24" Ga.	6	-	-
Car, muck, push type, 24 CFT, 18" Ga.	5	-	-
Compressor, air, 360 CFM, 100 PSI	2	150	-
Drill, diamond core, air powered	1	-	-
Drill, drifter, 3" Bore	1	-	90
Drill, jackhammer, without pusher leg	8	-	480
Drill, stoper, 3" bore	2	-	180
Drill, sinker, 2½" bore	2	-	100
Fan, Blower	4	20	-
Fan, Ventilating	1	-	-
Feed and shell, drifter	1	-	-
Level, engineers	1	-	-
Locomotive, diesel, 5-ton	1	-	10,000
Locomotive, compressed air	1	-	-
Mucking machine, 12 CFT bucket	2	-	12,000
Oilers, drill line	13	-	-
Pumps, centrifugal, 20 HP	3	-	-
Pusher leg, jackhammer	8	-	-
Receiver, air, 12' x 5'	1	-	-
Scraper, hoe type, 30-inch	4	-	-
Slusher, compressed air, 8 HP	4	-	-
Transit, engineers	1	-	-
Trucks, pickup, 3/4 ton	2	-	-
Miscellaneous equipment			
Total Equipment Cost for 50 ton-per-day Lode Gold Mine			

APPENDIX III (Continued)

II. Mill

Item Description	Quantity	Total HP	Total Weight (#)	Total Cost f.o.b. Fairbanks
Receiving grizzly	1	-	11,000	$ 1,600
50-ton coarse ore bin, complete with supports and chutes	1	-	9,100	3,900
30" x 10' apron feeder, complete with receiving hopper, roller chain drive and 10 HP motor	1	10.0	7,160	6,375
Stationary grizzly	1	-	2,700	230
10" x 16" single toggle jawcrusher, complete with guard, drive and motor	1	20.0	6,400	6,015
Coarse ore belt conveyor, 18" wide, 37' long, complete with frame, impact idlers and drive	1	2.0	1,200	1,835
Fine ore bin, 50-ton live capacity, complete with supports and chutes	1	-	9,100	3,900
Rack and pinion gates	2	-	400	280
Belt feeder, 12" x 20', complete with motor and drive	1	1.0	2,000	2,940
4' x 8' Ball mill, complete with liners drum feeder, drive, and 50 HP motor	1	50.0	32,000	18,560
12" x 18" duplex jig, complete, with 1 HP motor	1	1.0	1,600	2,230
4' x 12' amalgamation plate	2	-	1,150	2,230
Fabricated mercury trap	2	-	1,000	500
24" x 16' spiral classifier, complete with motor and drive	1	2.0	4,900	4,395
Size 6S Wilfley table, complete with motor	1	1.5	3,100	2,450
10 CFT fabricated steel sump	1	-	150	60
22" x 2" middling return sand pump, complete with motor and drive	1	3.0	550	950
40 CFT fabricated tailings sump	1	-	500	250
2" x 2" tailings sand pump, complete with motor and drive	1	1.0	450	825
50 gallon drums for table concentrate	70	-	-	350
42" x 48" amalgamating unit, complete	1	8.5	9,000	6,720
Bullion recovery equipment	1	-	800	1,000
Tailings sampler, complete with motor and sampling head	1	0.5	500	1,065
3-ton bridge crane for crushing area	1	3.0	4,370	1,995
5-ton bridge crane for grinding area	1	5.0	10,950	3,150
Chutes and launders	-	-	8,500	4,250
Miscellaneous equipment	-	-	-	5,140
Total costs of mill machinery and equipment for 50 ton-per-day gold mill				$83,195

APPENDIX IV

DETAILED DESCRIPTIONS AND COSTS OF MINE AND MILL EQUIPMENT FOR ONE HUNDRED TON-PER-DAY LODE GOLD OPERATION

Item Description	Quantity	Total HP	Total Weight (#)	Total Cost f.o.b. Fairbanks
I. Mine				
Same as for 50 TPD mine operation				
II. Mill				
Receiving grizzly	1	-	11,000	$ 1,600
Bin, coarse ore, 100 ton, complete with supports and chutes	1	-	14,000	6,000
Feeder, apron, 30" x 10', complete with receiving hopper, roller chain drive, 10 HP motor	1	10.0	7,160	6,375
Grizzly, stationary	1	-	2,700	230
Jawcrusher, single toggle, 10" x 16" complete with guard, drive and motor	1	20.0	6,400	6,015
Conveyor, belt, coarse ore, 18" wide, 37' long, complete with motor, frame, impact idlers, and drive	1	2.0	1,500	2,535
Bin, fine ore, 100 ton live capacity, complete with supports and chutes	1	-	14,000	6,000
Gates, rack and pinion	2	-	400	280
Feeder, belt, 12" x 20', complete with motor and drive	1	1.0	2,000	2,940
Ball mill, 5' x 8', complete with liners, drum feeder, drive and motor	1	75.0	41,000	27,280
Duplex jig, 12" x 18", complete with motor	1	1.0	1,600	2,230
Plates, amalgamation, 4' x 12'	2	-	6,150	2,230
Mercury traps, fabricated	2	-	1,000	500
Classifier, spiral, 36" x 16', complete with motor and drive	1	3.0	6,200	5,500
Wilfley table, size 6S, complete with motor	1	1.5	3,100	2,450
Sump, steel, 10 CFT, fabricated	1	-	150	60
Pump, sand, middling return, 2" x 2", complete with motor and drive	1	3.0	550	950
Sump, tailings, 40 CFT, fabricated	1	-	500	250
Pump, sand, tailings, 2" x 2", complete with motor and drive	1	1.5	450	870
Drums, 50 gallon, for table concentrate	70	-	-	350
Amalgamating unit, 42" x 48", complete	1	8.5	9,000	6,720
Bullion recovery equipment	1	-	800	1,000
Sampler, tailings, complete with motor and sampling head	1	0.5	500	1,065
Crane, bridge, 3-ton, for crushing area	1	3.0	4,370	1,995

APPENDIX IV (Continued)

Item Description	Quantity	Total HP	Total Weight (#)	Total Cost f.o.b. Fairbanks
Crane, bridge, 5-ton, for grinding area	1	5.0	10,950	3,150
Chutes and launders	-	-	8,500	4,250
Miscellaneous equipment	-	-	-	60
Total costs of mill machinery and equipment for 100 ton-per-day gold mill				$92,825

APPENDIX V

DETAILED DESCRIPTIONS AND COSTS OF MINE AND MILL EQUIPMENT FOR FIVE HUNDRED TON-PER-DAY LODE GOLD OPERATION

I. Mine

Item Description	Quantity	Total HP	Total Weight (#
Block, dump, retractable, Granby type	1	-	
Blocks, slusher	30	-	
Breaker, paving	1	-	60
Buildings, Miscellaneous	6	-	
Car, muck, Granby type, 90 CFT, 24" Ga.	8	-	
Car, muck, push type, 24 CFT, 18" Ga.	5	-	
Compressor, air, 867 CFM, 100 PSI	2	400	
Drill, diamond core			
Drill, jackhammer, without pusher leg	16	-	960
Drill, drifter, 3" bore	1	-	90
Drill, stoper, 3" bore	3	-	270
Drill, sinker, 2½" bore	2	-	100
Fan, main ventilating	1	-	
Fan, blower	10	50	
Feed and shell, drifter	1	-	
Level, engineers	1	-	
Locomotive, diesel, 6-ton	1	-	
Locomotive, compressed air	2	-	
Mucking machine, 12 CFT bucket	3	-	
Oilers, drill, line	20	-	
Pumps, centrifugal	3	-	
Pusher leg, jackhammer	16	-	
Receiver, air, 12' x 5'	2	-	
Scraper, hoe type, 30-inch	9	-	
Slusher, compressed air	9	72	
Transit, mine	1	-	
Truck, pickup	3	-	
Miscellaneous equipment	-	-	

Total equipment cost for mine, 500 ton-per-day operation

APPENDIX V (Continued)

II. Mill

Item Description	Quantity	Total HP	Total Weight (#)	Total Cost f.o.b. Fairbanks
Grizzly, 12" fabricated	1	-	10,000	$ 1,450
Bin, coarse ore, 23½' x 24', complete with supports and chutes	1	-	70,000	23,000
Feeder, apron, 30" x 14', complete with receiving hopper, drive and 10 HP motor	1	10.0	9,960	8,900
Grizzly, pulsating magnet, 36", complete with motor	1	5.0	2,890	2,550
Jawcrusher, single toggle, 15" x 24", complete with V-belt drive, guard, and 50 HP motor	1	50.0	14,300	15,445
Conveyor, coarse ore, belt, 18" x 37', complete with impact idlers, supports drive and motor	1	3.0	2,000	2,590
Electromagnet, tramp iron	1	-	580	1,430
Screen, vibrating, 3' x 8' single deck	1	5.0	2,400	2,990
Crusher, cone, 3', complete with 100 HP 1200 RPM high torque motor, feed hopper, air radiated oil cooler, compression mounts and immersion oil heater	1	100.0	19,030	26,020
Conveyor, belt, fine ore, 18" x 43', complete with impact idlers, supports, drive and motor	1	3.0	3,500	3,350
Conveyor, reversible, 12" x 20', complete with motor and drive	1	2.0	1,000	1,630
Chute, double wing, with motorized flop gate	1	1.5	1,500	820
Bin, 250-ton live capacity, ore, complete with supports and chutes	2	-	32,430	13,000
Indicators, bin level	2	-	-	1,020
Gates, rack and pinion	3	-	600	410
Feeders, belt, 12" x 20', complete with loading hoppers, impact idlers, motor and drive	2	2.0	4,000	5,880
Scales, belt	2	-	2,200	4,180
Ball mills, 7' x 8', complete with liners, drum feeder, drive and high torque 250 HP motor	2	500.0	190,000	102,555
Jigs, duplex, 16" x 24", complete with motor	2	3.0	4,000	5,120
Classifier, spiral, 54" x 19', complete with motor and drive	2	10.0	27,000	18,160
Amalgamation unit, 42" x 48", complete with motor and drive	1	8.5	8,955	5,920
Retorting and bullion recovery equipment	1	-	800	1,000
Ball mill, 3' x 3', complete with spout feeder, motor and drive, and liners	1	15.0	11,000	7,180
Classifier, spiral, 9" x 7'-10", complete with motor and drive	1	0.5	600	1,450
Conditioners, 4' x 4', complete with motors and tanks	2	4.0	2,600	3,210

APPENDIX V (Continued)

II. Mill (Continued)

Item Description	Quantity	Total HP	Total Weight (…
Cells, flotation, 56" x 56", complete with motors and drives	12	120.0	80,000
Thickener, concentrate, 6' dia. x 5' deep, complete	1	0.5	2,300
Pump, concentrate filter feed, 1¼" x 1"	1	1.5	320
Filter, disc, 4' dia. x 4 disc, complete with vacuum equipment and accessories	1	1.0	6,000
Bin, filtercake storage, 10-ton, fabricated	1	-	800
Feeder, screw, 6" dia., complete with motor, drive and accessories	2	2.0	1,600
Dryer, 24" x 15'	1	7.5	13,000
Elevator, bucket, belt, 5" x 3½", 15' centers complete with motor and drive	1	1.5	900
Bin, concentrate storage, 20-ton, fabricated, complete with supports and chute	1	-	1,600
Thickener, 15' x 8', complete with motor, drive and tank	1	1.5	8,000
Sump, clear water, 5,000 gallon, fabricated	1	-	10,300
Pump, recirculating water, 3" x 3", complete with motor, supports, and drive	1	5.0	600
Tank, head, with overflow pipe	1	-	600
Pump, duplex diaphragm, 6"	1	5.0	4,200
Sump, tailings, 5' x 5', with agitator	1	2.0	1,500
Pump, sand, tailings disposal, 3" x 3", complete with motor and drive	1	3.0	700
Initial ball charge			72,000
Crane, bridge, 3-ton	2	6.0	8,740
Crane, 5-ton	1	5.0	10,950
Chutes and launders and miscellaneous equipment			

APPENDIX VI

MINING STATISTICS

Item	50 TPD	100 TPD
Number of Mine Shifts Per Day	1	2
Number of Days Per Week	6	7
Number of Stopes Required Per Shift	3	3
Number of Tons Per Stope Per Shift	21	21
Number of Operating Weeks Per Year	49	49
Number of Operating Days Per Year (including paid holidays)	294	343
Number of Operating Days Per Year (excluding paid holidays)	287	336
Number of Men Per Stope Per Shift	3	3
Tons Per Shift Per Man (Stope Labor)	6.30	6.45
Tons Per Shift Per Man (Total Labor)	2.86	2.85
Number of Operating Shifts Per Stope	116	116
Number of Operating Days Per Stope	116	70
Number of Tons Ore Per Stope	2450	2450
Number of Tons Development Per Stope	661	661
Ratio of Development Tonnage/Ore Tonnage	0.27/1.0	0.27/1.0
Estimated Man-Shifts to Develop 1 Stope	100	100
Tonnage Factor (Rock in Place)	12.0 $ft.^3/T$	12.0 $ft.^3/T$
Tonnage Factor (Broken Rock)	20.0 $ft.^3/T$	20.0 $ft.^3/T$
Tonnage Per Year	18,522	36,015
Number of Years for Amortization	5	5
Proved Ore Reserve, Tons	92,610	180,075
Operating Period Counted by Working Capital	3 mos.	3 mos.
Period of Pre-production Development	15 mos.	15 mos.

APPENDIX II (Continued)

Category	Item	Description	Unit Cost f.o.b. Fairbanks
Electrical Materials (Continued)	Wire, dual conductor with ground wire, insulated	#14	$ 0.09/ft.
	"	#12	0.16/ft.
	"	#10	0.22/ft.
	Wire, dual conductor without ground wire, insulated	#14	0.08/ft.
	"	#12	0.10/ft.
	"	#10	0.17/ft.
	Wire, single conductor, insulated	#12	0.05/ft.
	"	#10	0.07/ft.
	"	#8	0.09/ft.
	"	#6	0.13/ft.
	"	#4	0.19/ft.
Foodstuffs	Canned Goods:	Beets, 303 can	0.32/each
		Fruit Cocktail, 303 can	0.36/each
		Ham, 1-pound can	1.34/each
		Orange Juice, frozen, 6 oz.can	0.43/each
		Pears, 303 can	0.45/each
		Peas, 303 can	0.39/each
		Pineapple Juice, 46 oz. can	0.50/each
		Tomatoes, 303 can	0.36/each
	Meats:	Bacon	1.19/lb.
		Beef, hamburger	0.63/lb.
		Beef, rib roast	1.14/lb.
		Beef, round steak	1.29/lb.
		Beef, sirloin steak	1.56/lb.
		Chicken, fryer	0.79/lb.
		Ham	1.32/lb.
		Pork, chops	1.21/lb.
	Produce:	Bananas	0.38/lb.
		Carrots	0.31/lb.
		Lettuce	0.39/lb.
		Onions	0.24/lb.
		Oranges	1.62/doz.
		Potatoes	0.13/lb.
		Tomatoes	0.52/lb.
	Miscellaneous:	Beans, dried	0.29/lb.
		Bread	0.49/loaf

APPENDIX II (Continued)

Category	Item	Inside Diameter ½"	3/4"	1"	
Plumbing Supplies (Continued)	Nipple, 12-inch	$0.32	$0.46	$0.61	$0
	Pipe, galvanized, steel	0.18	0.22	0.30	0
	Plugs	0.12	0.14	0.16	0
	Tee, standard	0.17	0.24	0.54	0
	Union	0.42	0.47	0.69	0
	Valve, check	2.18	2.65	3.58	3
	Valve, gate	2.45	2.94	4.28	5
	Valve, globe	2.05	2.43	3.22	

Category	Item	Description	
Electrical Materials	Bulbs, light, 110 v.	100 watt	
	Bulbs, light, 220 v.	100 watt	
	Conduit, steel, galvanized,	thinwall,	1/2" dia.
	"	"	3/4" dia.
	"	"	1" dia.
	"	"	2" dia.
	Motors, electric AC	Single phase,	1/2 HP
	"	"	3/4 HP
	"	"	1 HP
	"	"	2 HP
	"	"	5 HP
	"	"	7½ HP
	Motors, electric, AC	3 phase	½ HP
	"	"	3/4 HP
	"	"	1 HP
	"	"	2 HP
	"	"	5 HP
	"	"	7½ HP
	Insulators, porcelain	2-inch x 1 5/8" dia.	
	Panels, circuit breaker, 240 v.	60 a., 1 breaker	
	"	100 a., 1 breaker	
	"	100 a., 2 breakers	
	"	100 a., 3 breakers	
	Transformers	240 v. to 120 v. 1 KW	

APPENDIX II (Continued)

Category	Item	Description	Unit Cost f.o.b. Fairbanks
Miscellaneous Hardware and Tools (Continued)	Socket and wrench set	215 pieces	$254.00/each
	Steel, drill	7/8" Hex., 4-foot	13.13/each
	"	7/8" Hex., 6-foot	16.58/each
	"	7/8" Hex., 8-foot	21.90/each
	"	1" Hex., 4-foot	14.50/each
	"	1" Hex., 6-foot	18.20/each
	"	1" Hex., 8-foot	23.00/each
	Sticks, tamping	1-inch round, 8-foot	1.00/each
	Wrenches, crescent	8-inch	2.12/each
	"	16-inch	7.04/each
	Wrenches, pipe	14-inch	4.05/each
	"	24-inch	9.14/each
Explosives	Caps, blasting	#6, 100 per box	5.75/box
	Caps, electric		29.80/100
	Crimpers, cap		2.95/each
	Dynamite, ditching	50-pound box, 1¼" x 8"	23.90/box
	Dynamite, gelatin, 40%	50-pound box, 1¼" x 8"	22.50/box
	Dynamite, nitroglycerine, 40%	50-pound box	21.00/box
	E-Cord		30.00/1000 ft.
	Fuse, safety	100-foot roll	3.50/roll
	Galvanometer, blasting		
	Machine, blasting	50-cap, plunger-type	125.00
	Prills, ammonium nitrate, pre-mix	50-pound sack	6.50/sack
	Primacord, reinforced		37.25/1000 ft.
	Spitter, lead	25-foot roll	1.75/roll
	Wire, lead		0.04/ft.

Plumbing Supplies

Item (Inside Diameter)	½"	3/4"	1"	1¼"	2"	3"	
Bushings	$0.19	$0.22	$0.24	$0.31	$ 0.42	$ -	Each
Caps	0.16	0.22	0.26	0.35	0.57	-	"
Compound, pipe joint, bulk					0.39/lb.		
Coupling, regular	0.17	0.22	0.32	0.39	0.74	3.68	"
Coupling, reducing	0.22	0.25	0.39	0.51	0.90	-	"
Elbow, 90 degree	0.12	0.16	0.36	0.57	1.06	5.94	"
Elbow, 45 degree	0.25	0.34	0.40	0.67	1.25	5.60	"
Elbow, street	0.17	0.23	0.44	0.67	1.25	-	"
Nipple, 3-inch	0.10	0.12	0.17	0.21	0.35	-	"

APPENDIX VII

PRODUCTION AND DEVELOPMENT TONNAGES

Nominal Daily Ore Tonnage	Shift	Days Per Week	Ore Production (Tons) Per Day	Ore Production (Tons) Per Week	Development (Tons) Per Day	Development (Tons) Per Week
50 TPD	Day	6	63	378	17	102
100 TPD	Day	7	63	441	17	119
	Afternoon	7	42	294	12	84
Total			105	735	29	203
500 TPD	Day	7	168	1176	46	322
	Afternoon	7	168	1176	46	322
	Night	7	168	1176	46	322
Total			504	3528	138	966

APPENDIX VIII

LABOR REQUIREMENTS

Specific Type of Labor	Number of Individuals Re… 50 TPD	100 TPD
Mine:		
Miner - production	3	6
Miner - development	2	4
Miner - exploration	1	1
Miner's Helper - production	3	6
Miner's Helper - development	2	4
Miner's Helper - exploration	1	1
Timberman	3	6
Motorman	1	3
Slusherman	1	1
Nipper	1	3
Surfaceman	1	3
Maintenanceman	1	3
Blacksmith	0	0
Carpenter	0	0
Electrician	0	0
Mechanic	0	0
Mechanic's Helper	0	0
Machinist	0	0
Lampman	0	0
Truckdriver	1	1
Payroll Clerk (Timekeeper)	0	0
Clerk	1	1
SUB-TOTAL	22	43
Mill:		
Millman	1	4
Crusher Operator	1	2
Maintenanceman	3	2
Greaseman	3	3
Packing Plant Operator	0	0
Heating Plant Operator	0	0
Clerk	0	0
Electrician	0	0
Truckdriver	0	0
SUB-TOTAL	8	11
TOTAL	30	54

APPENDIX IX

STAFF REQUIREMENTS

Specific Position	Number of Individuals Required: 50 TPD	100 TPD	500 TPD
Mine:			
Mine Superintendent	0	0	1
Mine Foreman	1	1	1
Assistant Mine Foreman	0	0	2
Shift Foreman	1	2	7
Mine Engineer	1	1	1
Mine Geologist	0	0	1
Assayers - Samplers - Surveyors	1	1	3
Office Manager	0	0	1
SUB-TOTAL	4	5	17
Mill:			
Mill Superintendent	0	0	1
Mill Foreman	1	1	0
Shift Foreman	0	1	4
SUB-TOTAL	1	2	5
Mine Manager	1	1	1
TOTAL	6	8	23
Staff/Labor Ratio	1/5	1/7	1/8

APPENDIX X

COSTS OF MATERIALS AND SUPPLIES BY OPERATIONAL PHASE

Operational Phase	Cost Per Ton of Ore: 50 TPD		100 TPD	
Mine:				
Drilling - production	$1.405		$1.335	
Drilling - development	0.761		0.723	
Drilling - Sub-total	$2.166		$2.058	
Blasting - production	1.414		1.343	
Blasting - development	0.675		0.641	
Blasting - Sub-total	$2.089		$1.984	
Mucking - development	$0.016		$0.015	
Slusher - production	0.035		0.033	
Track - development	0.329		0.313	
Timbering - production	2.806		2.666	
Timbering - development	0.401		0.381	
Timbering - Sub-total	$3.207		$3.047	
Haulage	$0.149		$0.142	
Miscellaneous	0.628		0.597	
SUB-TOTAL		$8.619		$8.189
Mill:				
Crushing	$0.758		$0.573	
Grinding and Classification	1.678		1.514	
Amalgamation	0.325		0.246	
Thickening, filtering, and flotation	-		-	
Refining	0.216		0.123	
Assaying	0.162		0.123	
Miscellaneous	0.704		0.614	
SUB-TOTAL		$3.843		$3.193
		$12.462		$11.382