5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.7. LARGE UNDERGROUND EXCAVATIONS

The costs derived from these curves apply to a horizontal opening driven with a two boom jumbo and LHD haulage a distance of 200 m. It is assumed the walls will be supported with rockbolts and wire mesh. If the material is to be hauled out of the mine, the tonnage attributed to excavating should be added to to the haulage curves for the period of time necessary to complete the excavation. It is assumed that all equipment needed for the excavation will be required for the mining operation, and will be considered in the mine equipment cost curve.

Total cost per meter is the sum of three separate cost curves (labor, supplies, and equipment operation) based on a face area (X), in square meters. The curves are valid for areas between 13.94 and 334.45 m^2, operating one shift per day. Daily operating cost is the product of meters of excavations per day and the total cost per meter.

BASE CURVES

(L) <u>Labor Operating Cost</u> $(Y_L) = 10.817(X)^{0.947}$

The operating labor costs are distributed as follows:

Direct labor...............	91%
Maintenance labor..........	9%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
Miners.....................	76%	$18.11
Helpers....................	19%	13.66
Motor operators............	5%	15.89

The average wage for labor is $17.16 per worker-hour (including burden and average shift differential).

(S) <u>Supply Operating Cost</u> $(Y_S) = 23.050(X)^{0.793}$

The supply cost consists of 66% explosives, 28% steel items, and 6% ventilation. Supplies include drill bits and steel, powder, caps, primer cord, water pipe, compressed air pipe, vent duct, rockbolts and wire mesh.

(E) <u>Equipment Operating Cost</u> $(Y_E) = 1.739(X)^{0.917}$

The equipment operating cost consists of 45% for overhaul and repair parts, 35% for tires, and 20% for fuel and lubrication. The equipment operating curve covers daily maintenance and overhaul parts and lubrication for drills, fans, LHD's, and roof bolters.

ADJUSTMENT FACTORS

Track Haulage Factor If track haulage is used, the LHD will be replaced by a battery locomotive, overshot mucker, and rail cars. Rubber-tired equipment is more expensive to operate than rail-mounted equipment. Therefore, to account for cost of the equipment and installing rail, multiply the costs obtained from the curves by the following factors:

Supply factor $(F_S) = 1.13$

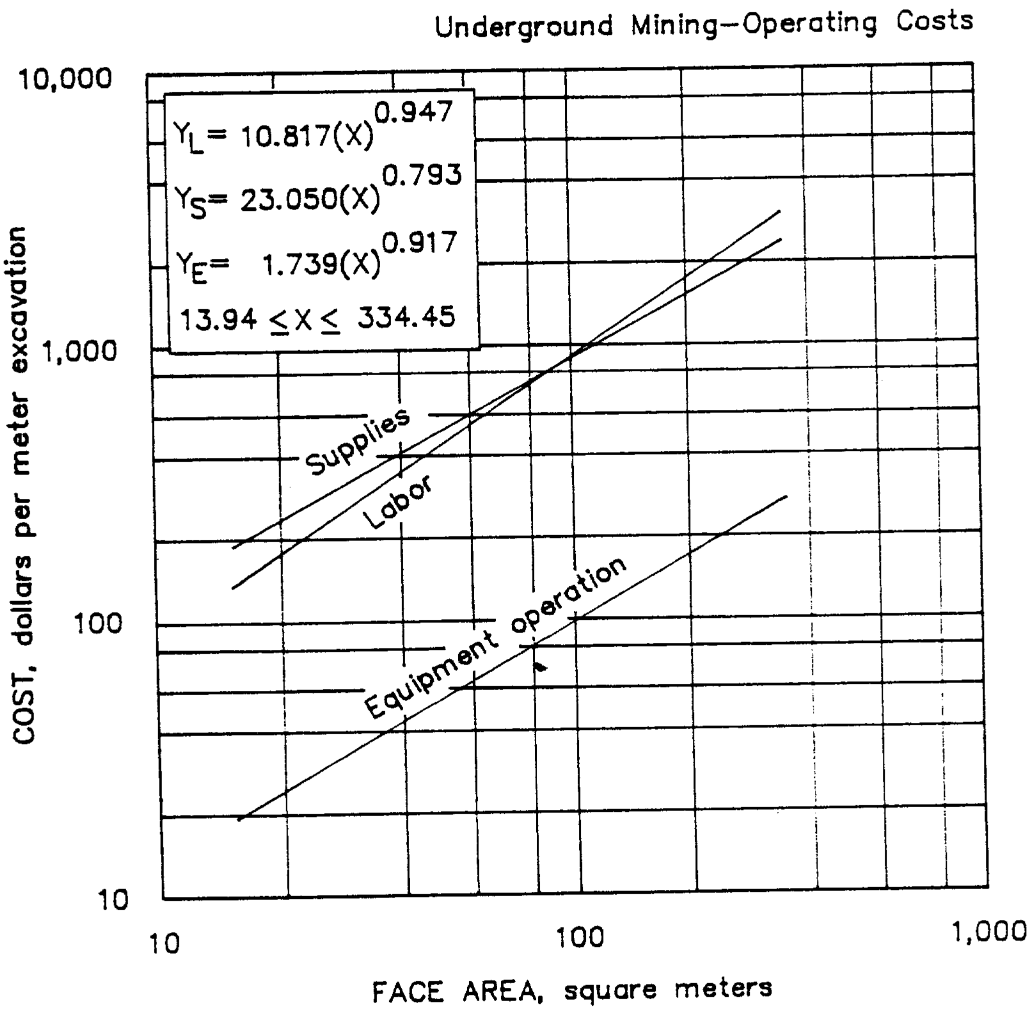
Equipment operation factor $(F_E) = 0.71$

Shotcrete Factor For additional expenses associated with coating the excavation to a shotcrete depth of 3.8 cm, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 1.05$

Supply factor $(F_S) = 1.59$

Equipment operation factor $(F_E) = 1.09$



5.2.1.7. Large underground excavations

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9. STOPE PREPARATION

Stope preparation includes any operation and excavation necessary to bring a stope into full-scale production. Stope preparation is, of course, different for every mining method, so each method is dealt with individually in the following sections. In general, however, costs derived from the following curves cover every operation and excavation needed to develop the stope for full capacity extraction, and to connect it with the main haulage system. A detailed list of items needed for individual methods is provided in each of the following sections. In order to obtain an accurate cost estimation, the evaluator must provide the dimensions and estimated tonnage of a typical stope designed for the deposit under evaluation.

Each operating cost must be calculated as a daily cost, that necessitates the amount of daily stope development required after production begins. One method to arrive at this daily cost is to use the following relationship:

daily cost = [cost per metric ton] x [(metric tons of minable ore - metric tons of ore developed prior to production) / (mine life, in days)].

Another method is to calculate the total number of stopes needed to mine the entire ore body, subtract the number of stopes developed during preproduction, and divide the remaining number of stopes by the mine life in days. This is the number of stopes to be developed on a daily basis to be used as a multiplier on the following stope preparation sections.

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.1. STOPE PREPARATION BLOCK CAVING

Items needed for preparation of a block caving stope include panel drifts, access drifts, grizzly drifts, undercut drifts, draw raises, transfer raises, and cave induction. All ore chutes, grizzlies, and support and reinforcement items are included in the curve. The curves cover blocks in horizontal area and of any height. Costs represent a system in which ore is moved to the main haulage level by gravity methods.

Total cost per block is the sum of three separate cost curves (labor, supplies, and equipment operation) based on a typical block plan view area (X), in square meters. The curves are valid for areas between 2,400 and 6,300 m^2, operating two shifts per day. The costs are then multiplied by the number of blocks developed per day to obtain a cost per day or the costs are divided by the metric tons per block to obtain a cost per metric ton.

BASE CURVES

(L) Labor Cost $(Y_L) = 573.198(X)^{0.881}$
The operating labor costs are distributed as follows:

Direct labor................	98%
Maintenance labor...........	2%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
Miners......................	72%	$18.31
Helpers.....................	24%	13.86
LHD operators...............	4%	16.09

The average wage for labor is $17.15 per worker-hour (including burden and average shift differential).

(S) Supply Cost $(Y_S) = 650.100(X)^{0.883}$
The supply cost consists of 26% steel items, 25% concrete, 20% timber, 18% blasting supplies, 5% contingency, 4% drill bits and steel, and 2% all other items. Supplies necessary for the development of a block caving stope include drill bits and steel, blasting agent, caps, timber, concrete, rail, water and compressed air pipe, ventilation ducting, rockbolts, electricity, and steel for ore chutes and grizzlies.

(E) Equipment Cost $(Y_E) = 11.355(X)^{0.885}$
The equipment operating cost consists of 76% for maintenance and overhaul parts, 9% for tires, 8% for fuel, and 7% for lubrication. The equipment curve covers

daily maintenance and overhaul parts, tires, fuel, and lubrication. Equipment used in stope preparation for block caving includes jacklegs, auxiliary fans, overshot muckers, locomotives, ore cars, LHD's, and fan drills.

ADJUSTMENT FACTORS

Nongravity Caving Factor If the ore is to be transferred to the main haulage system using slushers or LHD's, adjustments must be made to the costs. Multiply the costs obtained from the curves by the following factors:

Slushers:

Labor factor $(F_L) = 0.85$

Supply factor $(F_S) = 0.83$

Equipment operation factor $(F_E) = 0.99$

LHD's:

Labor factor $(F_L) = 0.60$

Supply factor $(F_S) = 0.84$

Equipment operation factor $(F_E) = 0.77$

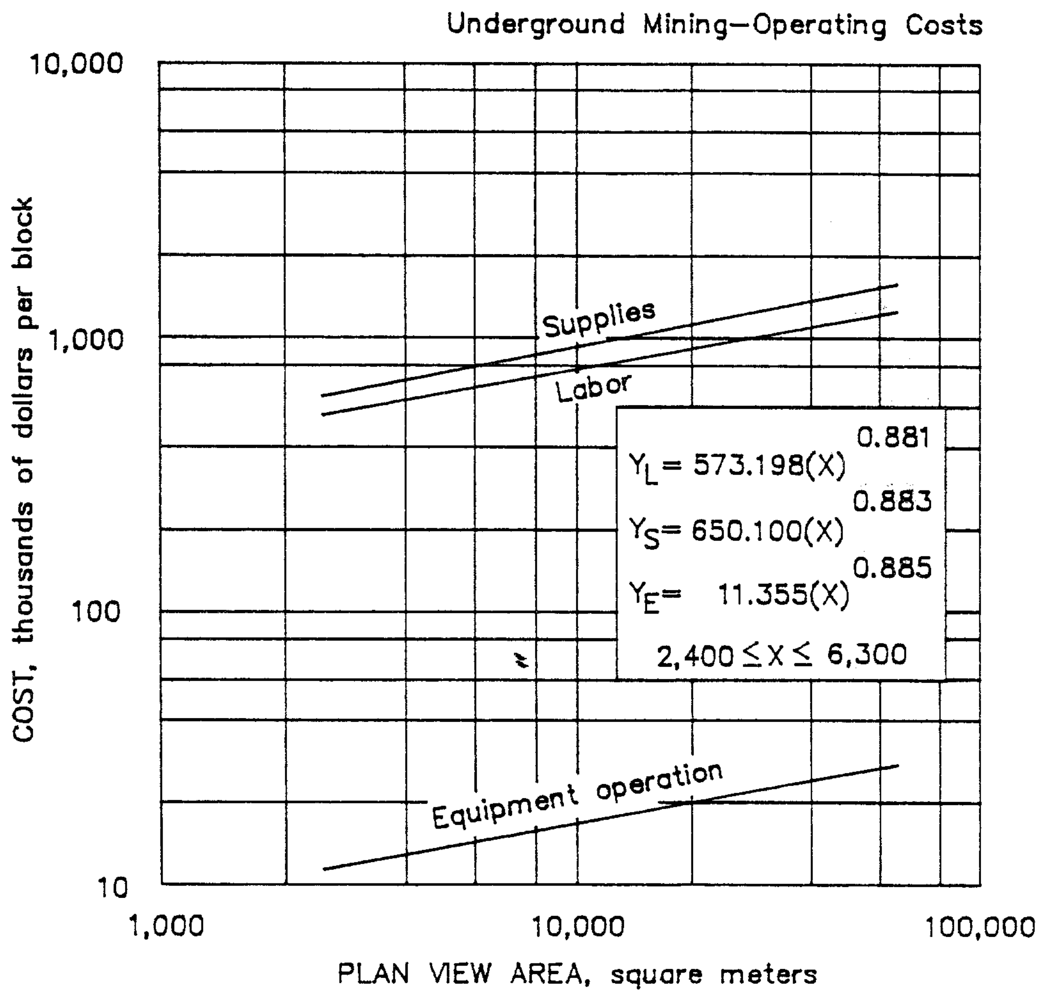
Rock Hardness Factor Block caving development costs are directly related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

Labor factor $(F_L) = 0.388(C)^{0.093}$

Supply factor $(F_S) = 0.579(C)^{0.054}$

Equipment operation factor $(F_E) = 0.716(C)^{0.033}$

where C = compressive rock strength, in pounds per square inch.



5.2.1.9.1. Stope preparation
BLOCK CAVING

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.2. STOPE PREPARATION CONTINUOUS MINING

Continuous miner stopes are initiated with multientry panels directly off the main haulage level. The method changes little from the initial cuts to the completion of the stope. The cost of the main haulage level cannot be included in the stope preparation costs since many stopes benefit from this one entry. Because the cost per ton of excavating the production entries from the haulage level is the same as that for production mining, no stope preparation cost is required.

For operating cost estimation, daily haulageway development must be sufficient to open up the number of new stopes required to maintain production.

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.3. STOPE PREPARATION CUT AND FILL

Items needed for preparation of a cut-and-fill stope include a crosscut from the main haulageway, a blind raise access cut with two ore chutes, a manway, a timber slide, and an initial bottom sill cut. The curves cover stopes ranging from 2.4 m wide by 61.0 m long to 4.9 m wide by 106.7 m long and of any reasonable height.

Total cost per stope is the sum of three separate cost curves (labor, equipment operation, and supplies) based on a plan view area (X), product of length and width, in square meters. The curves are valid for areas between 140 and 540 m^2, operating two shifts per day. The costs are then multiplied by the number of stopes developed per day to obtain a cost per day or the costs are divided by the metric tons per stope to obtain a cost per metric ton.

BASE CURVES

(L) Labor Cost $(Y_L) = 4,422.948(X)^{0.369}$
The operating labor costs are distributed as follows:

Direct labor................	97%
Maintenance labor...........	3%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

	Small (140 to 340 m^2)	Large (340 to 540 m^2)	Av salary per hour (base rate)
Miners......................	69%	73%	$18.31
Helpers.....................	25%	23%	13.86
Motor operators.............	6%	4%	16.09

The average wage for labor is $17.13 per worker-hour (including burden and average shift differential).

(S) Supply Cost $(Y_S) = 16,203.090(X)^{0.197}$
The supply cost consists of 31% timber, 25% blasting supplies, 24% steel items, 5% drill bits and steel, 5% contingency, 4% ventilation material, 3% sandfill preparation material, and 3% electricity and miscellaneous items. Supplies necessary for the development of a cut-and-fill stope include drill bits and steel, blasting agent, caps, timber, rail, ballast, steel pipe, ventilation ducting, rockbolts, burlap, electricity, and steel for ore chutes.

(E) Equipment Cost $(Y_E) = 311.270(X)^{0.201}$
The equipment operating cost consists of 85% for maintenance and overhaul parts, 8% for lubrication, and 7% for ground engaging components. The equipment curve covers maintenance and overhaul parts, ground engaging components, and lubrication. Equipment used in stope preparation for cut-and-fill mining includes

jacklegs, stopers, jackhammers, auxiliary fans, overshot muckers, locomotives, ore cars, and slushers.

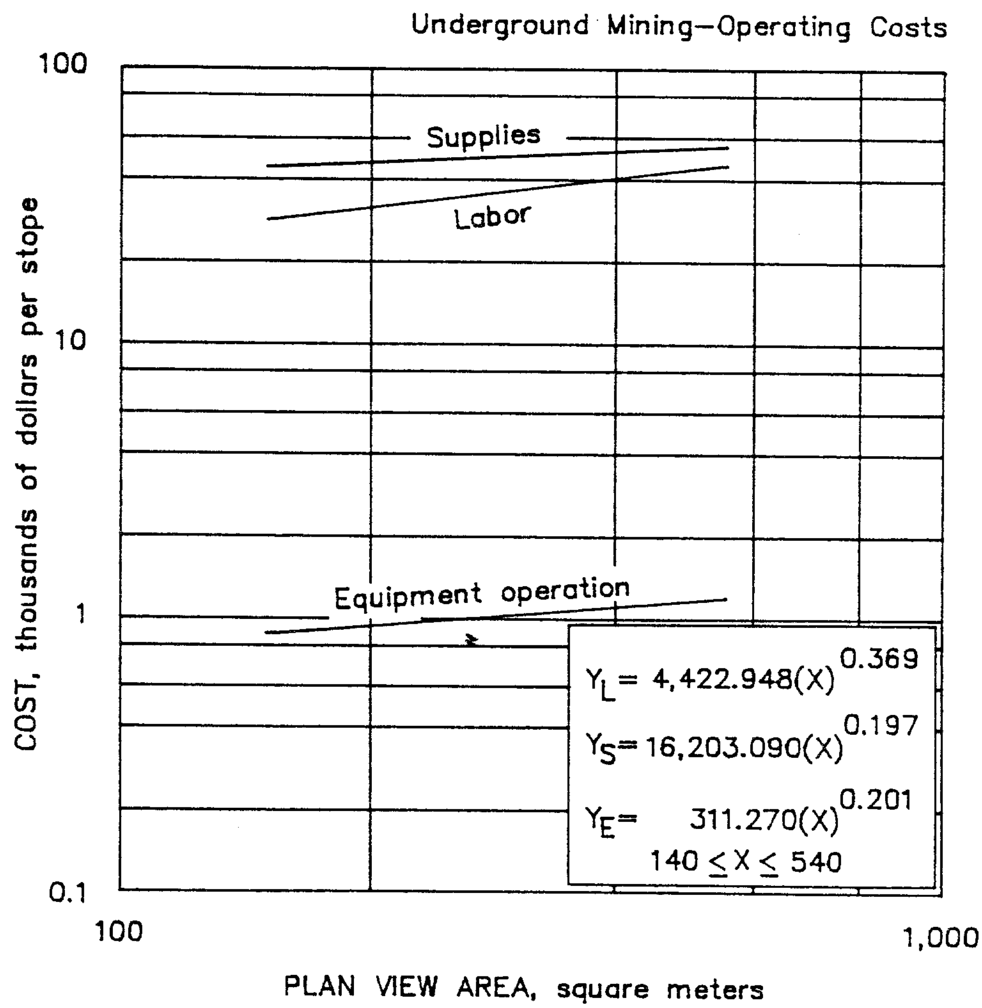
ADJUSTMENT FACTOR

Rock Hardness Factor Cut-and-fill stope development costs are directly related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the cut-and-fill stope preparation equations by the following factors (base rock strength = 31,700 psi):

Labor factor $(F_L) = 0.403(C)^{0.090}$

Supply factor $(F_S) = 0.590(C)^{0.052}$

Equipment operation factor $(F_E) = 0.716(C)^{0.033}$
where C = compressive rock strength, in pounds per square inch.



5.2.1.9.3. Stope preparation
CUT AND FILL

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.4. STOPE PREPARATION
LONGHOLE-SUBLEVEL

Items needed for preparation of a sublevel-longhole stope include sublevels, a bottom sill cut, a scram drift, crosscuts connecting the bottom sill and scram drifts, an access raise, and a slot raise. The curves cover stopes ranging from 5.4 m wide by 61.0 m high by 76.2 m long to 18.3 m wide X 121.9 meters high by 152.4 m long.

Total cost per stope is the sum of three separate cost curves (labor, equipment operation, and supplies) based on a profile view area (X), product of length and height, in square meters. The curves are valid for areas between 4,600 and 18,600 m^2, operating two shifts per day. The costs are then multiplied by the number of stopes developed per day to obtain a cost per day or the costs are divided by the metric tons per stope to obtain a cost per metric ton.

BASE CURVES

(L) Labor Cost $(Y_L) = 357.256(X)^{0.685}$
The operating labor costs are distributed as follows:

Direct labor................	95%
Maintenance labor...........	5%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

	Small (4,600 to 11,600 m^2)	Large (11,600 to 18,600 m^2)	Av salary per hour (base rate)
Miners.....................	65%	65%	$18.31
Helpers....................	22%	22%	13.86
LHD operators..............	9%	8%	16.09
Utility workers............	3%	4%	15.94
Surveyors..................	1%	1%	15.08

The average wage for labor is $17.05 per worker-hour (including burden and average shift differential).

(S) Supply Cost $(Y_S) = 363.252(X)^{0.687}$
The supply cost consists of 46% blasting supplies, 16% steel items, 10% drill bits and steel, 9% ventilation materials, 9% timber, 5% contingency, and 5% electricity and miscellaneous items. Supplies necessary for the development of a sublevel-longhole stope include drill bits and steel, blasting agent, caps, timber, water and compressed air pipe, ventilation ducting, electricity, and rockbolts.

(E) Equipment Cost $(Y_E) = 23.555(X)^{0.707}$
The equipment operating cost consists of 57% for maintenance and overhaul parts, 19% for tires, 17% for fuel, and 7% for lubrication. The equipment curve covers

maintenance and overhaul parts, fuel, tires, and lubrication. Equipment used in stope preparation for sublevel-longhole mining includes jacklegs, auxiliary fans, LHD's, booster compressors, jumbo-mounted drifters, and air-track-mounted longhole drills.

ADJUSTMENT FACTOR

Rock Hardness Factor Sublevel-longhole stope development costs are directly related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

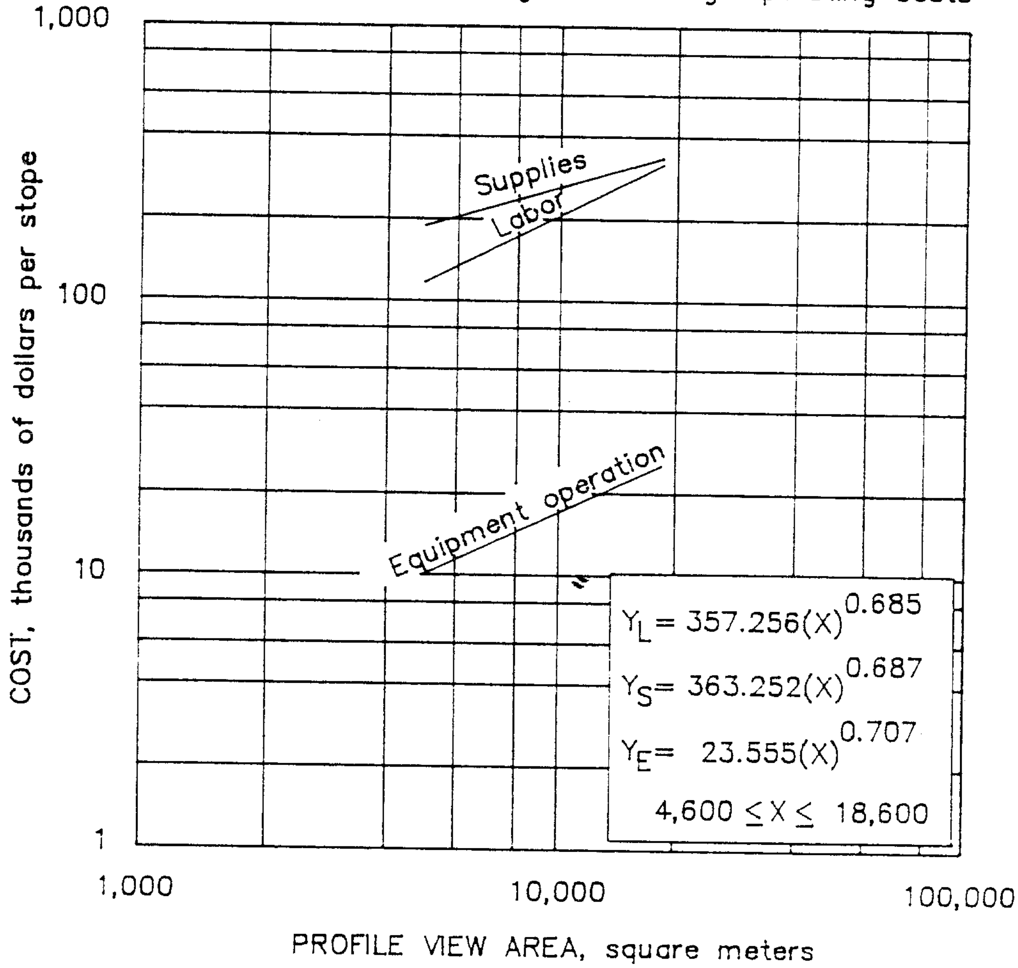
Labor factor $(F_L) = 0.392(C)^{0.093}$

Supply factor $(F_S) = 0.579(C)^{0.054}$

Equipment operation factor $(F_E) = 0.716(C)^{0.033}$

where C = compressive rock strength, in pounds per square inch.

Underground Mining—Operating Costs



5.2.1.9.4. Stope preparation
LONGHOLE/SUBLEVEL

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.5. STOPE PREPARATION RESUING

Items needed for preparation of a resuing stope include an access drift along the stope in the footwall, a blind raise access cut with two ore chutes and a manway, and a starter drift running the length of the stope. The blind raise runs the entire height of the stope, and both the raise and the starter drift are driven in ore and waste. Ore excavated during development is generally discarded as waste. The curves cover stopes ranging from 22.9 m long by 18.3 m high to 45.7 m long by 38.1 m high, and 1.5 m in width.

Total cost per stope is the sum of three separate cost curves (labor, equipment operation, and supplies) based on a profile view area (X), product of length and height, in square meters. The curves are valid for areas between 350 and 2,000 m^2, operating two shifts per day. The costs are then multiplied by the number of stopes developed per day to obtain a cost per day or the costs are divided by the metric tons per stope to obtain a cost per metric ton.

BASE CURVES

(L) Labor Cost $(Y_L) = 1,077.505(X)^{0.448}$
The operating labor costs are distributed as follows:

Direct labor................	97%
Maintenance labor...........	3%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
Miners......................	86%	$18.31
Helpers.....................	9%	13.86
Motor operators.............	5%	18.31

The average wage for labor is $17.80 per worker-hour (including burden and average shift differential).

(S) Supply Cost $(Y_S) = 4,004.706(X)^{0.290}$
The supply cost consists of 61% steel items, 13% blasting supplies, 12% timber, 6% ventilation materials, 4% drill bits and steel, 3% contingency, and 1% electricity and miscellaneous items. Supplies necessary for the development of a resuing stope include drill bits and steel, blasting agent, caps, timber, rail, ballast, steel pipe, ventilation ducting, electricity, and steel for ore chutes.

(E) Equipment Cost $(Y_E) = 24.097(X)^{0.499}$
The equipment operating cost consists of 67% for maintenance and overhaul parts, 16% for ground engaging components, 9% for fuel, and 8% for lubrication. The

equipment curve covers maintenance and overhaul parts, ground engaging components, fuel, and lubrication. Equipment used in stope preparation for resuing includes jacklegs, stopers, auxiliary fans, overshot muckers, locomotives, ore cars, and slushers.

ADJUSTMENT FACTOR

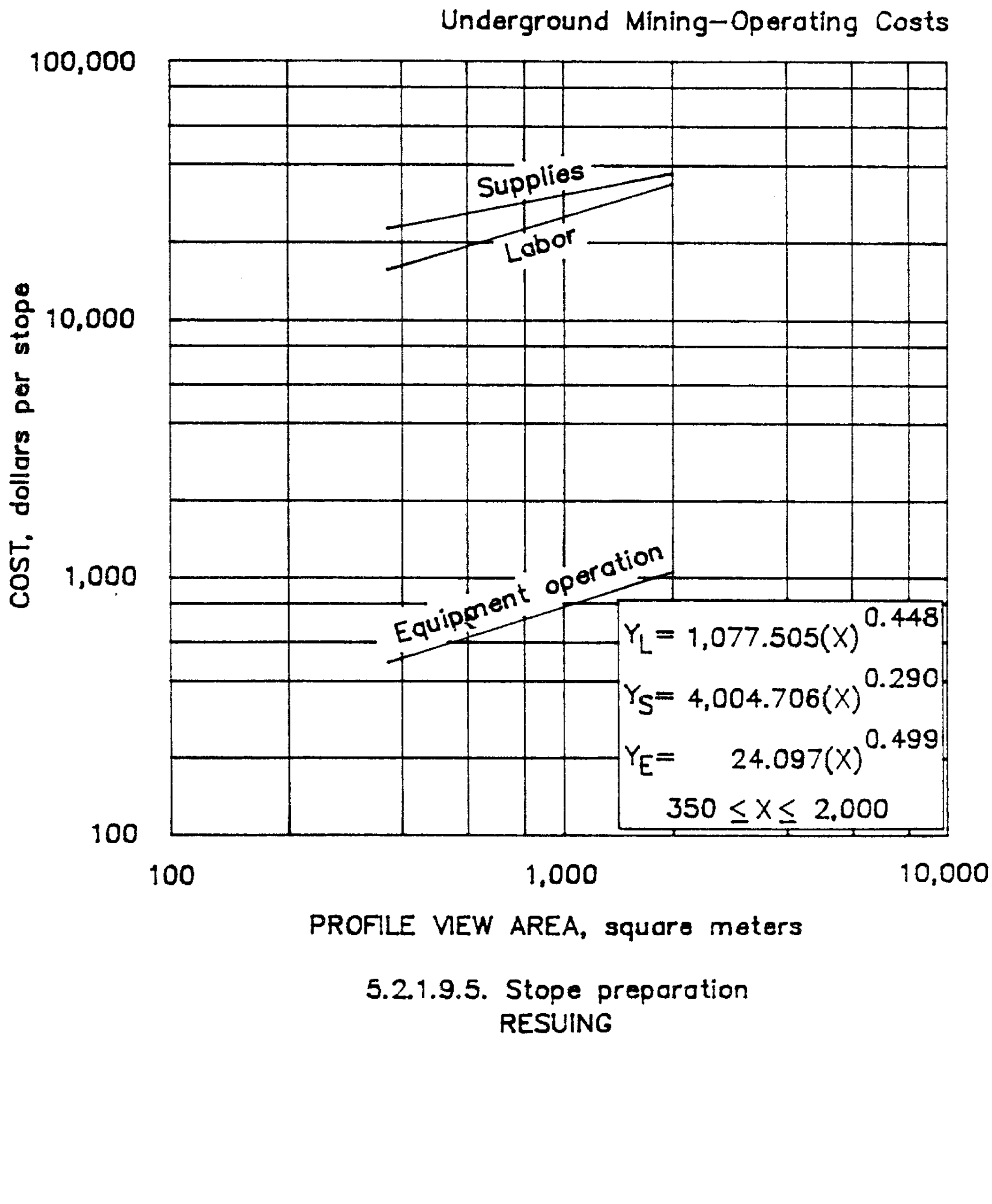
Rock Hardness Factor Resuing stope development costs are directly related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

Labor factor $(F_L) = 0.403(C)^{0.090}$

Supply factor $(F_S) = 0.590(C)^{0.052}$

Equipment operation factor $(F_E) = 0.716(C)^{0.033}$

where C = the compressive rock strength, in pounds per square inch.



5.2.1.9.5. Stope preparation
RESUING

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.6. STOPE PREPARATION
ROOM AND PILLAR, MEDIUM TO HARD ROCK

The main item needed to prepare a metallic room-and-pillar stope is an access drift from a main haulageway running the entire length of the panel. The curves cover panels ranging from 12,900 to 30,200 m^2 in horizontal area, and of any feasible height.

Total cost per stope is the sum of three separate cost curves (labor, equipment operation, and supplies) based on a plan view area (X), product of length and width in square meters. The curves are valid for areas between 12,900 and 30,200 m^2, operating two shifts per day. The costs are then multiplied by the number of stopes developed per day to obtain a cost per day or the costs are divided by the metric tons per panel to obtain a cost per metric ton.

BASE CURVES

(L) Labor Cost $(Y_L) = 4.019(X)^{0.890}$
The operating labor costs are distributed as follows:

Direct labor................	92%
Maintenance labor...........	8%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

	Small (12,900 to 21,550 m^2)	Large (21,550 to 30,200 m^2)	Av salary per hour (base rate)
Miners......................	46%	43%	$18.31
Helpers.....................	11%	22%	13.86
Utility workers.............	15%	12%	16.98
Utility helpers.............	15%	12%	13.86
Loader operators............	7%	8%	16.53
Surveyors...................	6%	3%	15.08

The average wage for labor is $16.53 per worker-hour (including burden and average shift differential).

(S) Supply Cost $(Y_S) = 2.686(X)^{0.997}$
The supply cost consists of 58% blasting supplies, 12% steel items, 11% drill bits and steel, 10% ventilation materials, 5% contingency, and 4% electricity and miscellaneous items. Supplies necessary for the development of a metallic room-and-pillar stope include drill bits and steel, blasting agent, caps, water and compressed air pipe, ventilation materials, electricity, and rockbolts.

(E) Equipment Cost $(Y_E) = 0.046(X)^{1.128}$
The equipment operating cost consists of 59% for maintenance and overhaul parts, 21% for fuel, 13% for tires, and 7% for lubrication. The equipment curve covers

maintenance and overhaul parts, fuel, tires, and lubrication. Equipment used in stope preparation for metallic room-and-pillar mining includes auxiliary fans, front-end loaders, jacklegs, scissor lifts, and jumbo-mounted drifters.

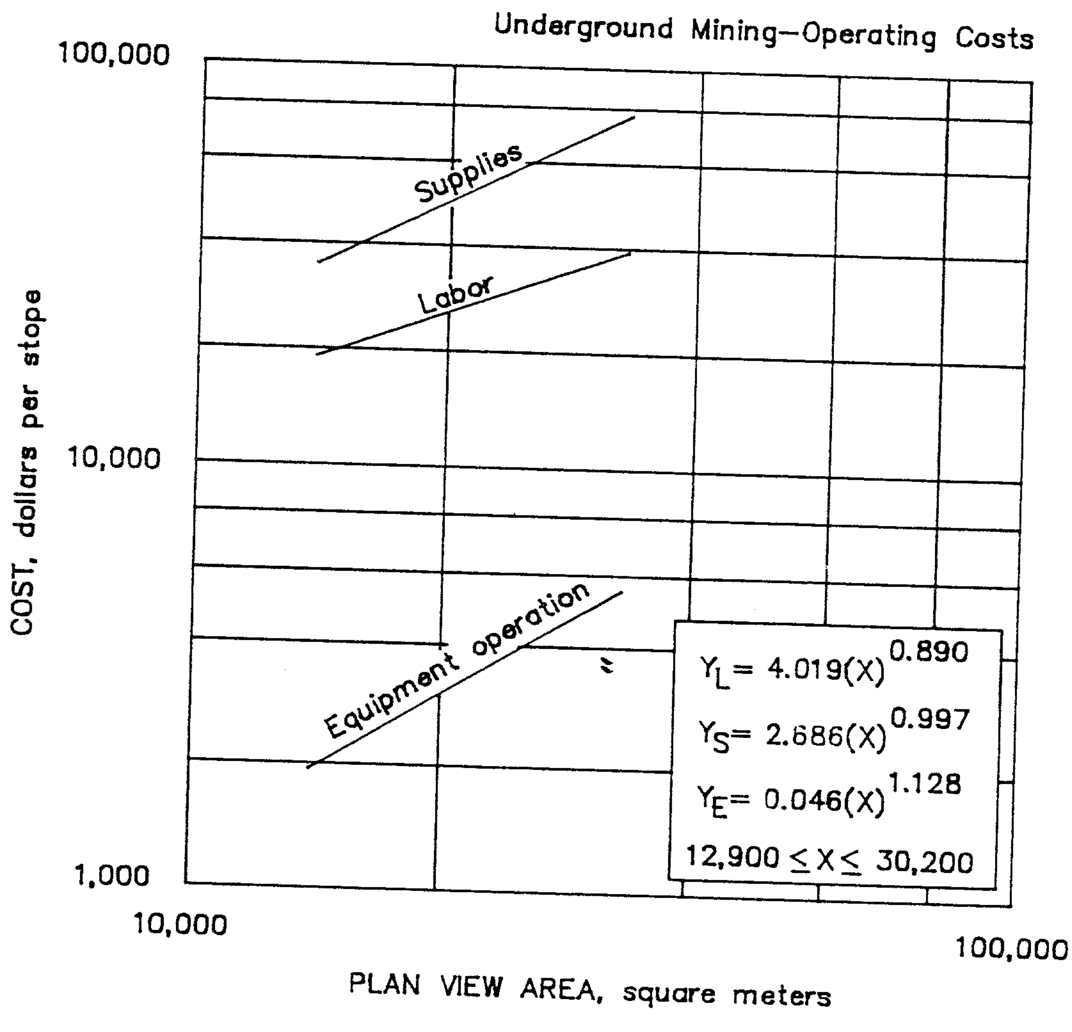
ADJUSTMENT FACTOR

Rock Hardness Factor Drifting productivity is directly related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

Labor factor $(F_L) = 0.388(C)^{0.093}$

Supply factor $(F_S) = 0.579(C)^{0.054}$

Equipment operation factor $(F_E) = 0.715(C)^{0.033}$
where C = compressive rock strength, in pounds per square inch.



5.2.1.9.6. Stope preparation
ROOM & PILLAR, MED.UM TO HARD ROCK

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.7. STOPE PREPARATION ROOM AND PILLAR, NONMETALLIC SOFT ROCK

The main item needed to develop a nonmetallic room-and-pillar stope consists of an access drift from a main haulageway running the entire length of the panel. The curves cover panels ranging from 14,800 to 33,500 m^2 in horizontal area, and of any feasible height.

Total cost per stope is the sum of three separate cost curves (labor, equipment operation, and supplies) based on a plan view area (X), product of length and width, in square meters. The curves are valid for areas between 14,800 and 33,500 m^2, operating two shifts per day. The costs are then multiplied by the number of stopes developed per day to obtain a cost per day or the costs are divided by the metric tons per panel to obtain a cost per metric ton.

BASE CURVES

(L) Labor Cost $(Y_L) = 43.903(X)^{0.557}$
The operating labor costs are distributed as follows:

Direct labor................	93%
Maintenance labor...........	7%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

	Small (14,800 to 24,150 m²)	Large (24,150 to 33,500 m²)	Av salary per hour (base rate)
Miners......................	15%	23%	$18.31
Loader operators............	10%	15%	16.53
Shuttle operators...........	10%	15%	16.09
Utility workers.............	29%	23%	16.98
Utility helpers.............	24%	16%	13.86
Surveyors...................	12%	8%	15.08

The average wage for labor is $16.30 per worker-hour (including burden and average shift differential).

(S) Supply Cost $(Y_S) = 20.909(X)^{0.632}$
The supply cost consists of 63% steel items, 10% drill bits and steel, 10% blasting supplies, 5% electricity, 4% ventilation materials, 4% contingency, and 4% miscellaneous items. Supplies necessary for the development of a nonmetallic room-and-pillar stope include drill bits and steel, blasting agent, caps, water and compressed air pipe, ventilation materials, electricity, and rockbolts.

(E) Equipment Cost $(Y_E) = 0.117(X)^{0.908}$
The equipment operating cost consists of 69% for maintenance and overhaul parts, 17% for tires, 11% for lubrication, and 3% for fuel. The equipment curve covers

maintenance and overhaul parts, fuel, tires, and lubrication. Equipment used in stope preparation for nonmetallic room-and-pillar mining includes roof bolters, ANFO trucks, undercutters, loaders, shuttle cars, portable transformers-rectifiers, and jumbo-mounted drifters.

ADJUSTMENT FACTOR

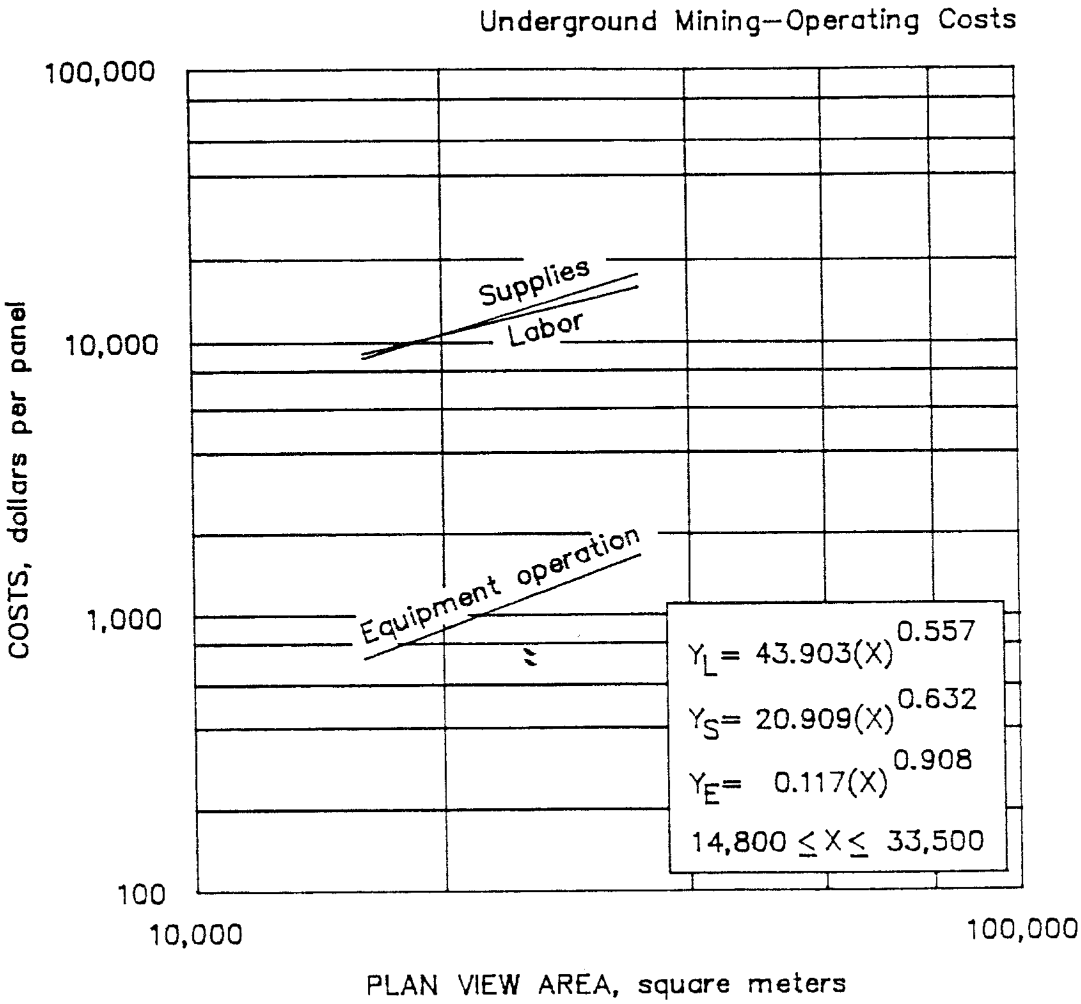
Rock Hardness Factor Drifting productivity is directly related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

Labor factor $(F_L) = 0.388(C)^{0.093}$

Supply factor $(F_S) = 0.579(C)^{0.054}$

Equipment operation factor $(F_E) = 0.715(C)^{0.033}$

where C = compressive rock strength, in pounds per square inch.



5.2.1.9.7. Stope preparation
ROOM & PILLAR, NONMETALLIC SOFT ROCK

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.8. STOPE PREPARATION SHRINKAGE

Items needed for preparation of a shrinkage stope include a bottom sill cut, a scram drift, crosscuts from the scram to the bottom sill drift, an access raise, and dog holes along the raise to connect with the stope as mining progresses. The curves are based on the assumption that ore will be drawn from the crosscuts using LHD's. Stopes ranging from 2.4 m wide by 45.7 m long to 5.5 m wide by 76.2 m long are covered by the curve. Stope height is fixed at 61 m.

Total cost per stope is the sum of three separate cost curves (labor, equipment operation, and supplies) based on a plan view area (X), product of length and width, in square meters. The curves are valid for areas between 100 and 440 m^2, operating two shifts per day. The costs are then multiplied by the number of stopes developed per day to obtain a cost per day or the costs are divided by the metric tons per stope to obtain a cost per metric ton.

BASE CURVES

(L) Labor Cost $(Y_L) = 9,917.618(X)^{0.329}$

The operating labor costs are distributed as follows:

Direct labor................	96%
Maintenance labor...........	4%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

	Small (100 to 270 m^2)	Large (270 to 440 m^2)	Av salary per hour (base rate)
Miners......................	70%	65%	$18.31
Helpers.....................	23%	27%	13.86
LHD operators...............	7%	8%	16.09

The average wage for labor is $17.09 per worker-hour (including burden and average shift differential).

(S) Supply Cost $(Y_S) = 7,445.199(X)^{0.335}$

The supply cost consists of 37% blasting supplies, 19% steel items, 15% timber, 11% ventilation materials, 9% drill bits and steel, 5% contingency, and 4% electricity and miscellaneous items. Supplies necessary for the development of a shrinkage stope include drill bits and steel, blasting agent, caps, timber, water and compressed air pipe, ventilation ducting, electricity, and rockbolts.

(E) Equipment Cost $(Y_E) = 373.610(X)^{0.388}$

The equipment operating cost consists of 64% for maintenance and overhaul parts, 20% for tires, 10% for fuel, and 6% for lubrication. The equipment curve covers maintenance and overhaul parts, fuel, tires, and lubrication. Equipment used in stope preparation for shrinkage mining includes stopers, jacklegs, auxiliary fans, LHD's, and jumbo-mounted drifters.

ADJUSTMENT FACTOR

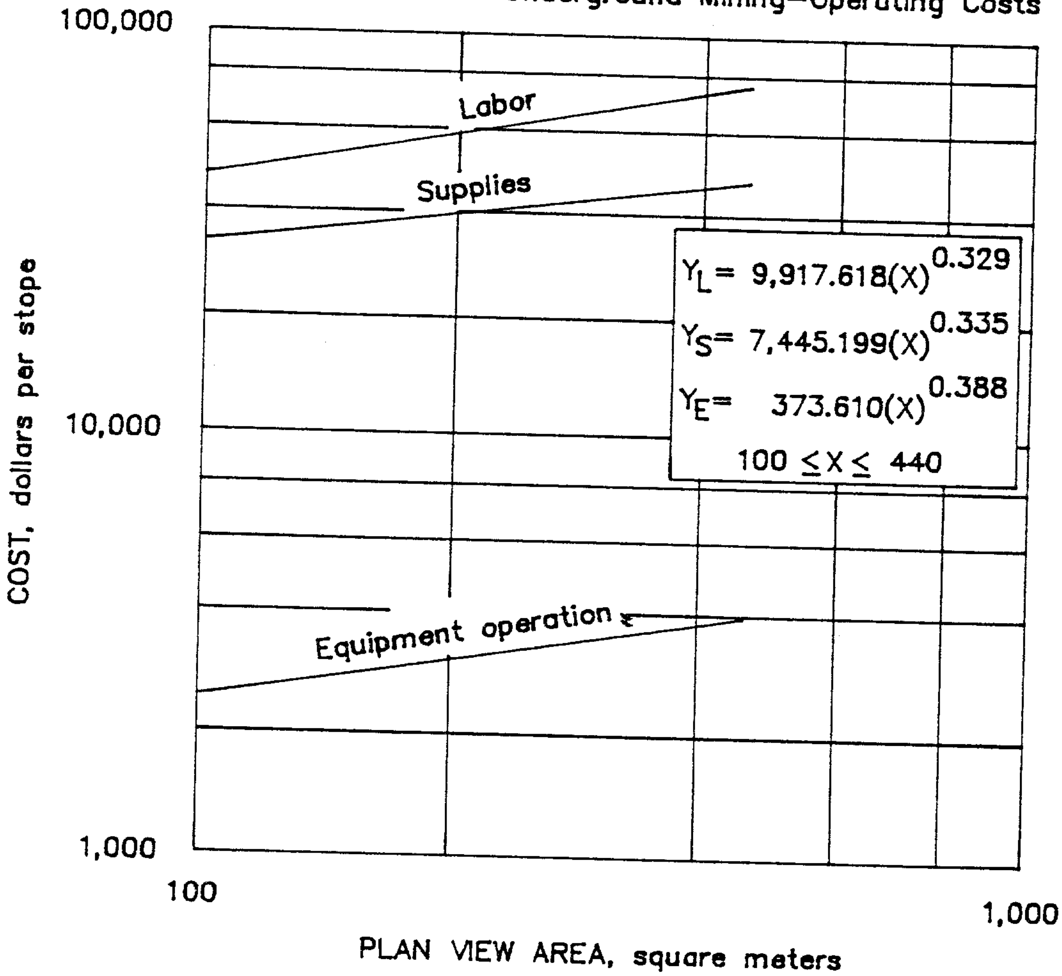
Rock Hardness Factor Shrinkage stope development costs are directly related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 of the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

Labor factor $(F_L) = 0.399(C)^{0.091}$

Supply factor $(F_S) = 0.585(C)^{0.053}$

Equipment operation factor $(F_E) = 0.717(C)^{0.033}$
where C = compressive rock strength, in pounds per square inch.

Underground Mining—Operating Costs



5.2.1.9.8. Stope preparation
SHRINKAGE

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.9. STOPE PREPARATION
SQUARE SET

Items needed for preparation of a square set stope include a crosscut from the main haulageway, an initial bottom sill cut, and a blind raise access cut with two ore chutes, a manway, and a timber slide. The curves cover stopes ranging from 2.4 m wide by 45.7 meters long to 4.9 m wide by 76.2 m long, and of any reasonable height.

Total cost per stope is the sum of three separate cost curves (labor, equipment operation, and supplies) based on a plan view area (X), product of length and width, in square meters. The curves are valid for areas between 100 and 400 m^2, operating two shifts per day. The costs are then multiplied by the number of stopes developed per day to obtain a cost per day or the costs are divided by the metric tons per stope to obtain a cost per metric ton.

BASE CURVES

(L) Labor Cost $(Y_L) = 6{,}114.261(X)^{0.340}$
The operating labor costs are distributed as follows:

Direct labor................	97%
Maintenance labor...........	3%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

	Small (100 to 250 m^2)	Large (250 to 400 m^2)	Av salary per hour (base rate)
Miners......................	69%	73%	$18.31
Helpers.....................	26%	24%	13.86
Motor operators.............	5%	3%	16.09

The average wage for labor is $16.93 per worker-hour (including burden and average shift differential).

(S) Supply Cost $(Y_S) = 17{,}393.433(X)^{0.208}$
The supply cost consists of 43% timber, 20% steel items, 19% blasting supplies, 9% contingency, 3% drill bits and steel, 3% ventilation materials, and 3% electricity and miscellaneous items. Supplies necessary for the development of a square set stope include drill bits and steel, blasting agent, caps, timber, blocking, rail, ballast, steel pipe, ventilation ducting, electricity, and steel for ore chutes.

(E) Equipment Cost $(Y_E) = 375.160(X)^{0.178}$
The equipment operating cost consists of 83% for maintenance and overhaul parts, 10% for lubrication, and 7% for ground engaging components. The equipment curve covers maintenance and overhaul parts, ground engaging components, and lubrication. Equipment used in stope preparation for square set mining includes jack-

legs, stopers, auxiliary fans, overshot muckers, locomotives, ore cars, and slushers.

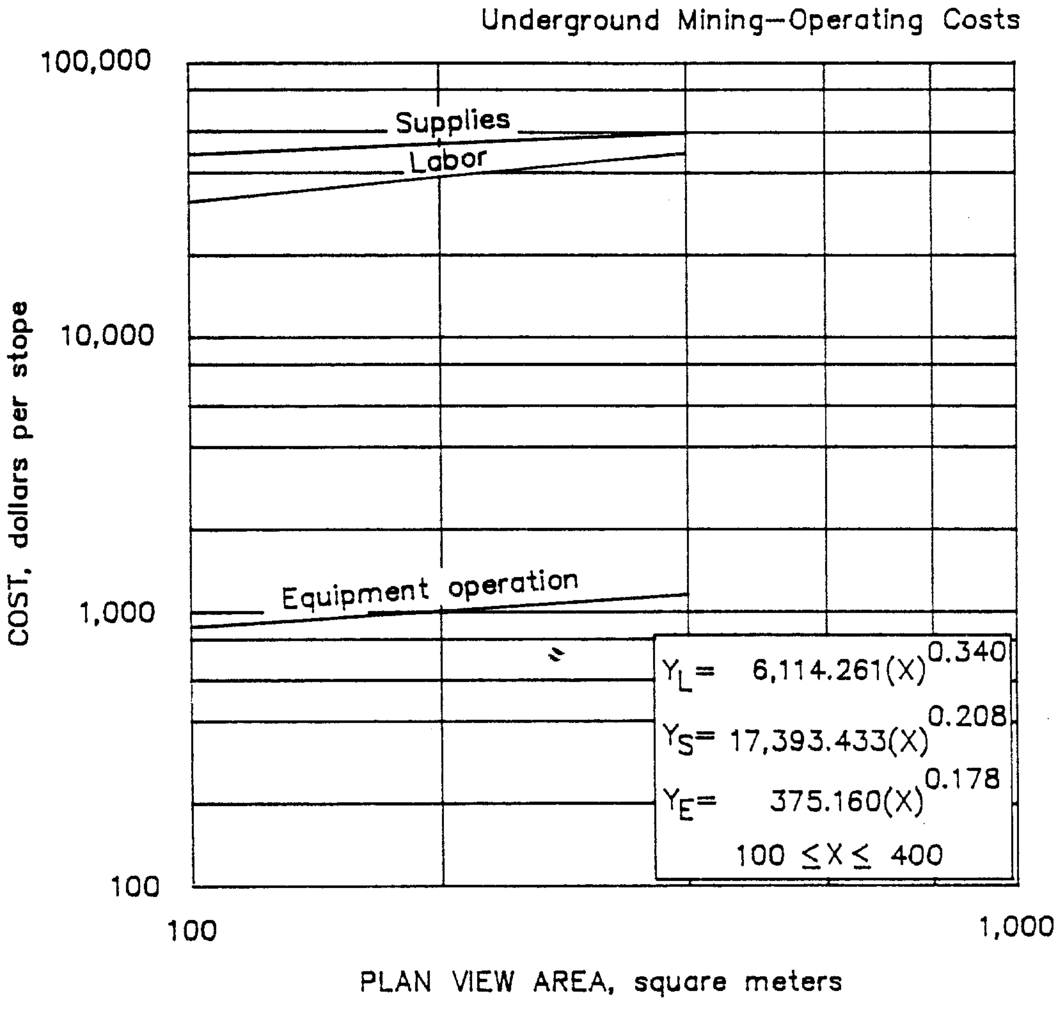
ADJUSTMENT FACTOR

Rock Hardness Factor Square set stope development costs are directly related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

Labor factor $(F_L) = 0.403(C)^{0.090}$

Supply factor $(F_S) = 0.590(C)^{0.052}$

Equipment operation factor $(F_E) = 0.716(C)^{0.033}$
where C = compressive rock strength, in pounds per square inch.



5.2.1.9.9. Stope preparation
SQUARE SET

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.1. PRODUCTION DEVELOPMENT

5.2.1.9.10. STOPE PREPARATION VERTICAL CRATER RETREAT

Items needed for preparation of a vertical crater retreat stope include a topsill cut, a bottom sill cut, and access drifts. The curves are based on the assumption that, during production, ore will be drawn from the bottom sill using remote controlled LHD's. Stopes ranging from 4.6 to 11.6 m wide are covered by the curves. Stope length is estimated at 61 m, but may be varied plus or minus 25% without affecting the accuracy of the calculations. Stope height must be within the limits of down-the-hole drills.

Total cost per stope is the sum of three separate cost curves (labor, equipment operation, and supplies) based on a plan view area (X), product of length and width, in square meters. The curves are valid for areas between 250 and 750 m^2, operating two shifts per day. The costs are then multiplied by the number of stopes developed per day to obtain a cost per day or the costs are divided by the metric tons per stope to obtain a cost per metric ton.

BASE CURVES

(L) Labor Cost $(Y_L) = 2{,}254.882(X)^{0.464}$
The operating labor costs are distributed as follows:

Direct labor................	94%
Maintenance labor...........	6%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

	Small (250 to 500 m^2)	Large (500 to 750 m^2)	Av salary per hour (base rate)
Miners......................	60%	64%	$18.31
Helpers.....................	24%	23%	13.86
LHD operators...............	10%	10%	16.09
Utility workers.............	4%	2%	15.42
Surveyors...................	2%	1%	15.08

The average wage for labor is $16.96 per worker-hour (including burden and average shift differential).

(S) Supply Cost $(Y_S) = 1{,}086.699(X)^{0.642}$
The supply cost consists of 51% blasting supplies, 20% steel items, 11% drill bits and steel, 10% ventilation materials, 5% contingency, and 3% electricity and miscellaneous items. Supplies necessary for the development of a vertical crater retreat stope include drill bits and steel, blasting agent, caps, water and compressed air pipe, ventilation ducting, electricity, and rockbolts.

(E) Equipment Cost $(Y_E) = 10.062(X)^{0.969}$
The equipment operating cost consists of 64% for maintenance and overhaul parts, 19% for tires, 11% for fuel, and 6% for lubrication. The equipment curve covers maintenance and overhaul parts, fuel, tires, and lubrication. Equipment used in stope preparation for vertical crater retreat mining includes LHD's, jacklegs, auxiliary fans, and jumbo-mounted drifters.

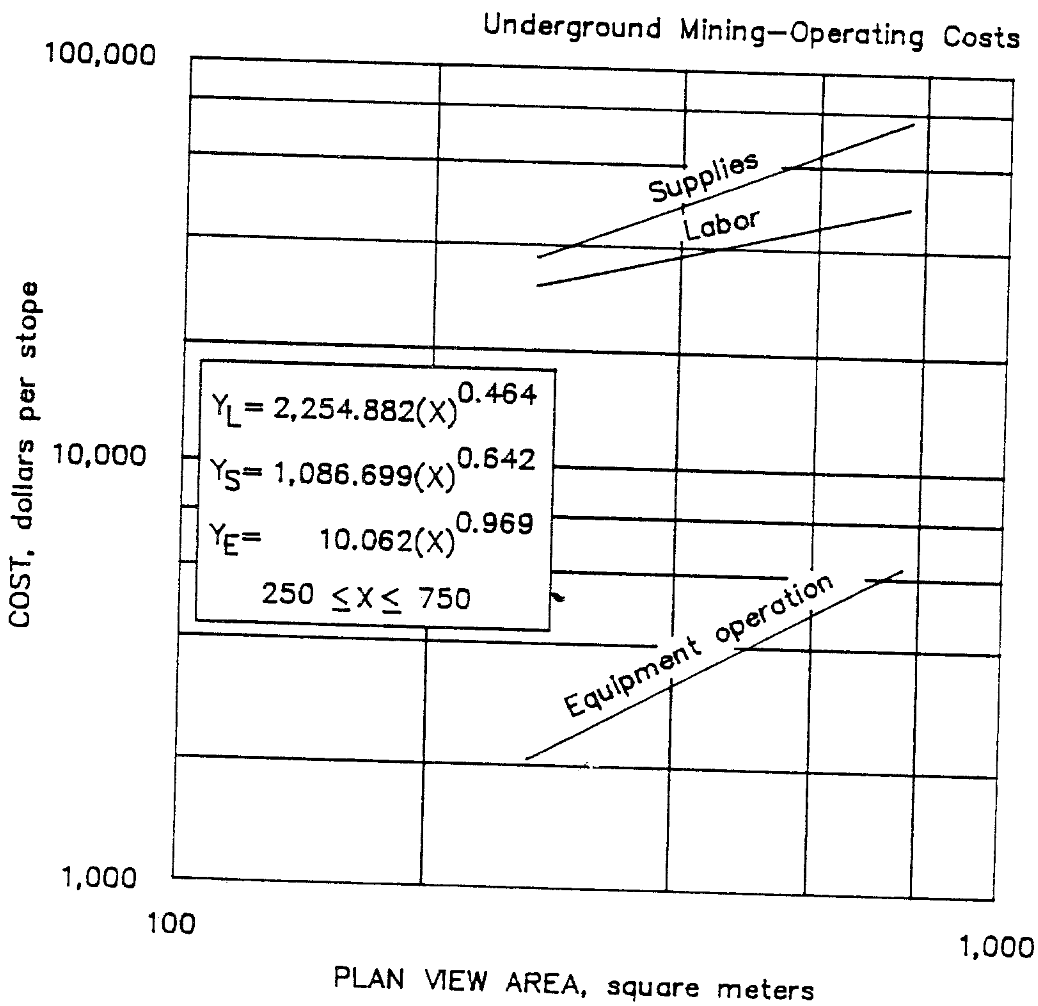
ADJUSTMENT FACTOR

Rock Hardness Factor Vertical crater retreat stope development costs are directly related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

Labor factor $(F_L) = 0.404(C)^{0.089}$

Supply factor $(F_S) = 0.584(C)^{0.053}$

Equipment operation factor $(F_E) = 0.716(C)^{0.033}$
where C = compressive rock strength, in pounds per square inch.



5.2.1.9.10. Stope preparation
VERTICAL CRATER RETREAT