

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.1.1. BLOCK CAVING
GRAVITY METHOD

Pure gravity block caving methods are best used when the ore is well fractured, and will break into fragments small enough to flow through a draw system without significant blockage. Productivity varies from 115 to 302 mt per worker-shift. Only the drawing of the ore during actual production is accounted for. Construction of grizzly drifts, crosscut drifts, panel drifts, and draw raises, as well as cave induction, re included in the stope preparation curves. Haulage of the ore from the stopes is covered in the haulage curves. Costs derived from the block caving curves apply to both block and panel caving methods.

The total daily cost is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 2,500 and 40,000 mtpd, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 15.726(X)^{0.671}$

The operating labor costs are distributed as follows:

Direct labor.....	100%
Maintenance labor.....	0%

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)
Hangup Workers.....	100%	\$18.31

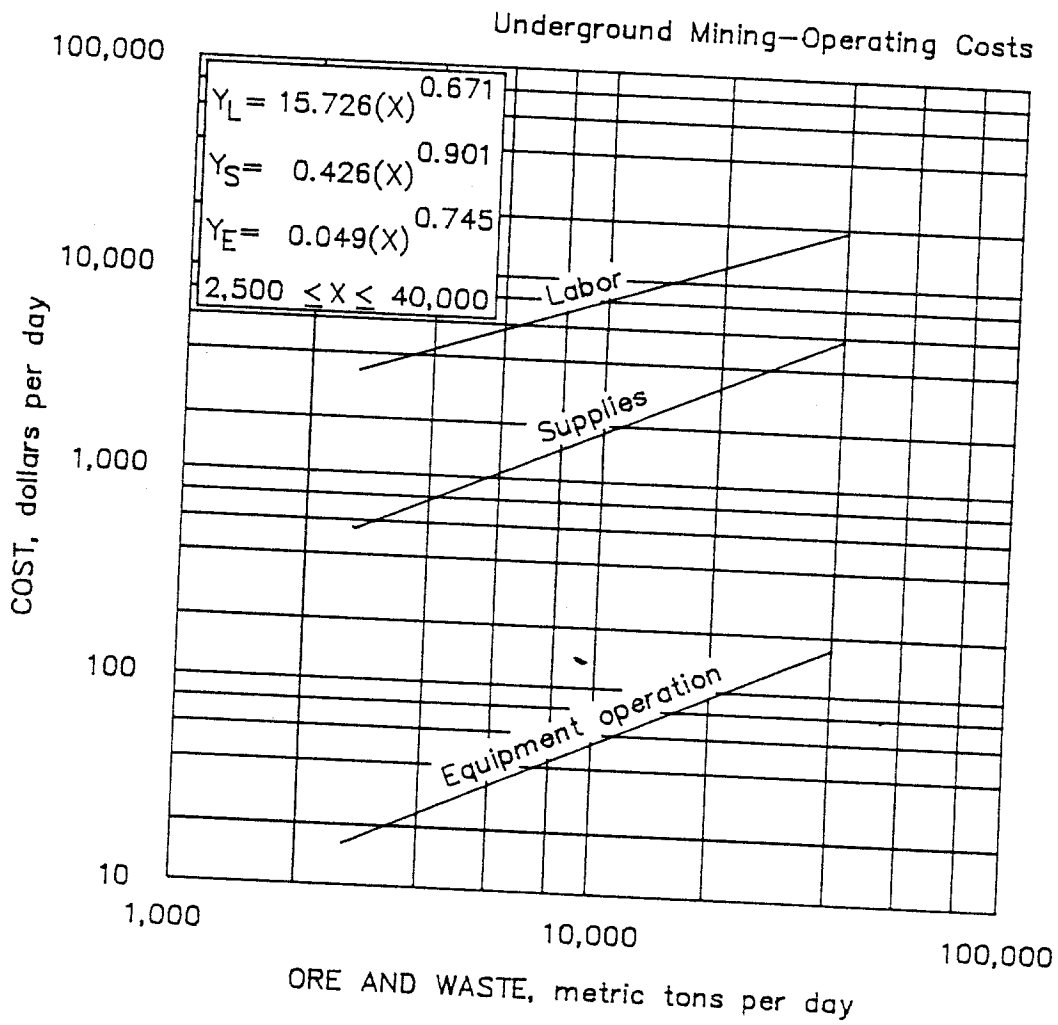
Average wage for labor is \$18.31 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.426(X)^{0.901}$

The supply cost consists of 37% blasting agent, 8% caps, 50% miscellaneous items, and 5% contingency. Supplies include blasting agent, caps, and miscellaneous items used for secondary blasting and supplemental drift support.

(E) Equipment Operating Cost $(Y_E) = 0.049(X)^{0.745}$

The equipment operating cost consists of 94% for maintenance and overhaul parts and 6% for lubrication. Equipment for gravity block caving consists only of jackleg drills used to assist in secondary blasting.



5.2.2.1.1. Block caving
GRAVITY METHOD

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.1.2. BLOCK CAVING
LOAD-HAUL-DUMP METHOD

LHD block caving methods are used when the ore is not well fractured, but will cave. The ore often breaks into fragments too large to be handled by slushers, and secondary blasting can be excessive. Haul length for the LHD units is estimated at 100 m. Productivity varies from 67 to 160 mt per worker-shift. Only the drawing of the ore during actual production is accounted. Construction of grizzly drifts, LHD drifts, panel drifts, and draw raises, as well as cave induction, are included in the stope preparation curves. Haulage of the ore from LHD-fed production chutes is covered in the haulage curves. Costs derived from the block caving curves apply to both block and panel caving methods.

The total daily cost is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 2,500 and 40,000 mtpd, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 22.650(X)^{0.692}$

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 (2,500 to 21,250 mtpd)	Large (21,250 to 40,000 mtpd)	Av salary per hour (base rate)
Hangup workers.....	78%	88%	\$18.31
LHD operators.....	22%	12%	\$16.53

Average wage for labor is \$18.06 per worker-hour (including burden and average shift differential).

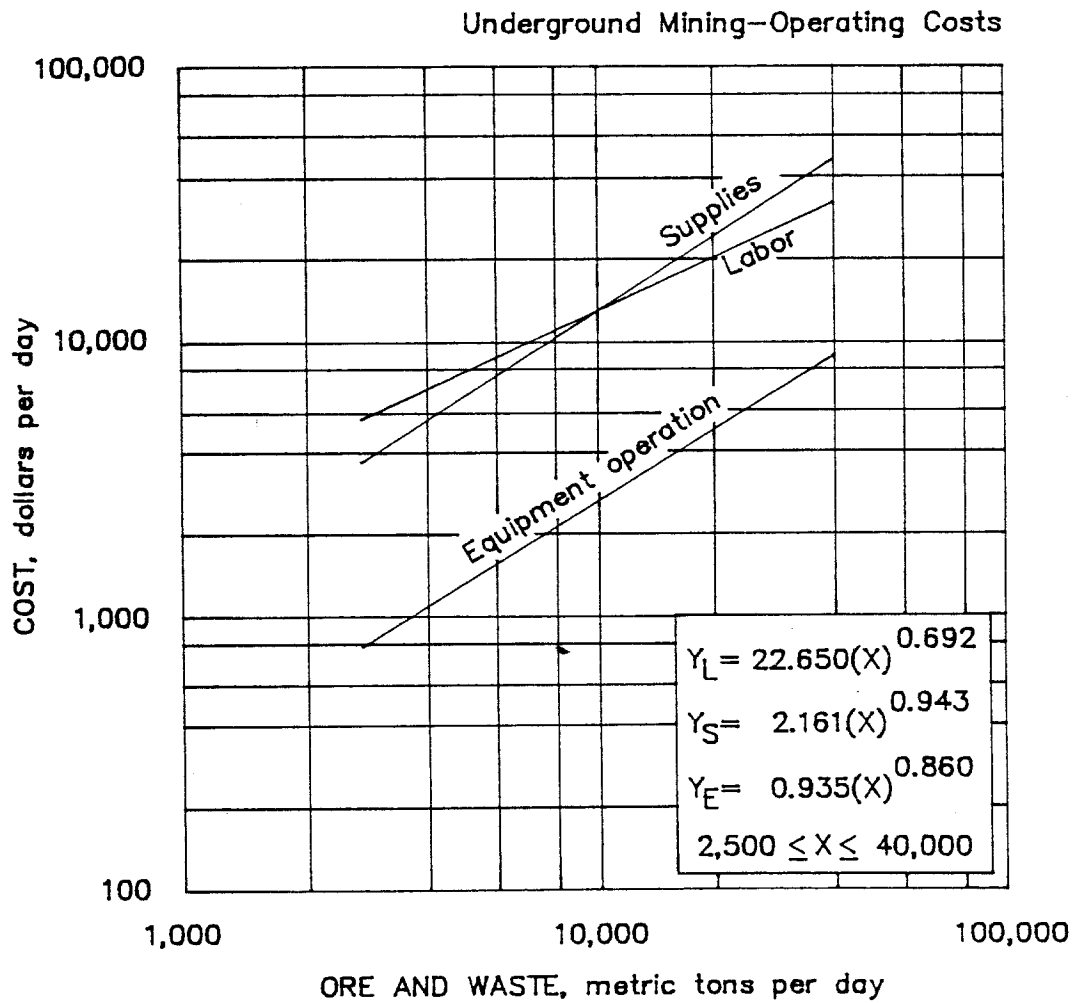
(S) Supply Operating Cost $(Y_S) = 2.161(X)^{0.943}$

The supply cost consists of 72% blasting agent, 17% caps, 6% miscellaneous items, and 5% contingency. Supplies include blasting agent, caps, and miscellaneous items used for secondary blasting and supplemental drift support.

(E) Equipment Operating Cost $(Y_E) = 0.935(X)^{0.860}$

The equipment operating cost consists of 49% for maintenance and overhaul parts, 28% for tires, 18% for fuel, and 5% for lubrication. The equipment curve covers maintenance and overhaul parts, fuel, tires, and lubrication. The equipment

used in LHD block caving includes LHD units for intermediate ore handling, and jackleg drills for secondary blasting.



5.2.2.1.2. Block caving
L.H.D. METHOD

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.1.3. BLOCK CAVING
SLUSHER METHOD

Slusher block caving methods are used when the ore is reasonably well fractured and breaks into fragments that can be handled by slushers. Productivity varies from 70 to 181 mt per worker-shift. Only the drawing of the ore during actual production is accounted. Construction of grizzly drifts, slusher drifts, panel drifts, and draw raises, as well as cave induction, are included in the stope preparation curves. Haulage of the ore from the stopes is covered in the haulage curves. Costs derived from the block caving curves apply to both block and panel caving methods.

The total daily cost is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 2,500 and 40,000 mtpd, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 23.197(X)^{0.681}$

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 (2,500 to 21,500 mtpd)	Large (21,250 to 40,000 mtpd)	Av salary per hour (base rate)
Hangup workers.....	68%	79%	\$18.31
Slusher operators.....	32%	21%	16.53

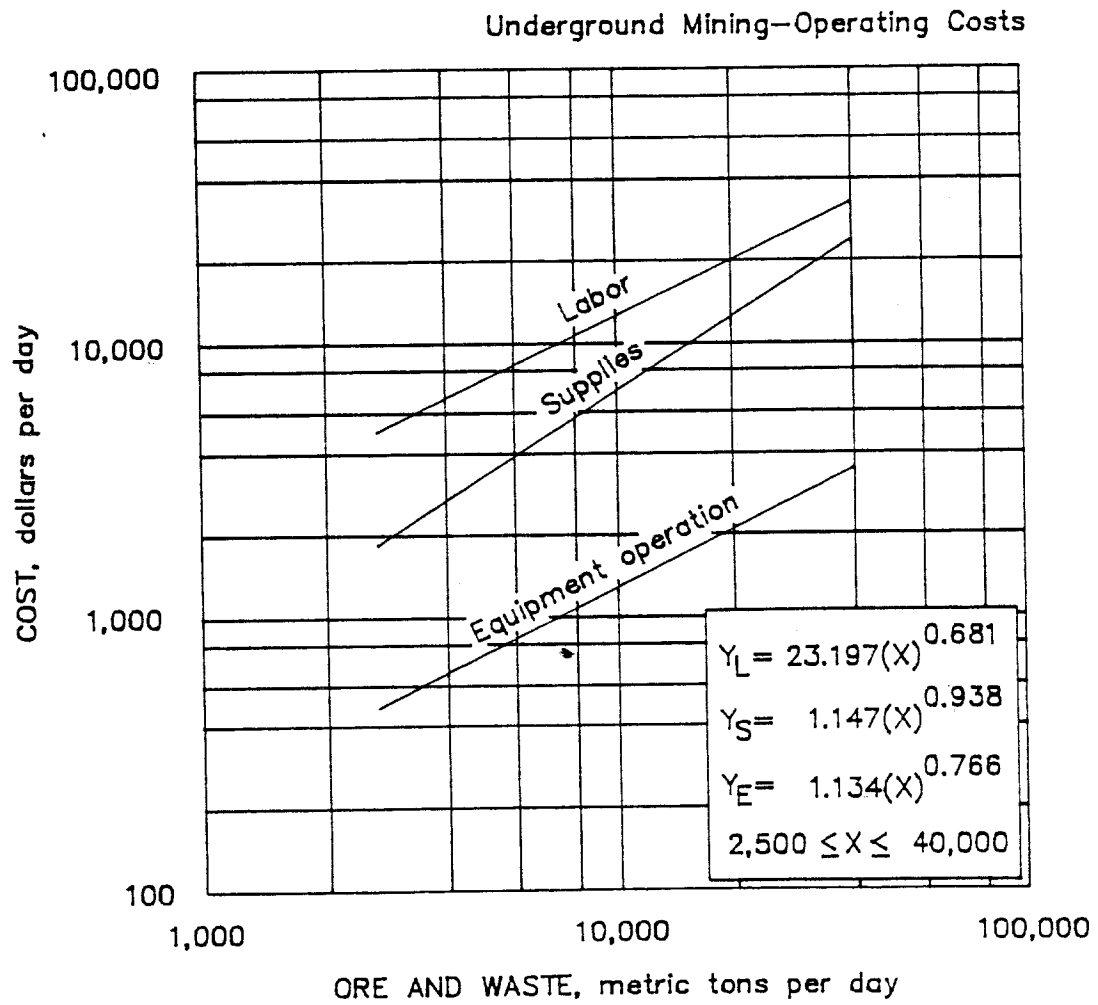
Average wage for labor is \$17.90 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 1.147(X)^{0.938}$

The supply cost consists of 67% blasting agent, 15% caps, 13% miscellaneous items, and 5% contingency. Supplies include blasting agent, caps, and miscellaneous items used for secondary blasting and supplemental drift support.

(E) Equipment Operating Cost $(Y_E) = 1.134(X)^{0.766}$

The equipment operating cost consists of 55% for maintenance and overhaul parts, 39% for electricity, and 6% for lubrication. The equipment used in slusher block caving includes slushers for inter-mediate ore handling, and jackleg drills for secondary blasting.



5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.2. CONTINUOUS MINING

The continuous miner curve is based on using continuous miners, shuttle cars, and rock bolters. Production rates average 100 mt per worker-shift. Only the cutting of the ore and haulage by shuttle car to a nearby conveyor loading point (approximately 100 m) are covered by the curve. Haulage by conveyor and other services are covered in other curve sections.

The total daily cost per day is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 2,000 and 30,000 mtpd, operating two shifts per day. The cost per metric ton is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 0.464(X)^{0.975}$

The operating labor costs are distributed as follows:

Direct labor.....	49%
Maintenance labor.....	51%

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

Miners.....	100%	Av salary per hour (base rate) \$18.31
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Average wage for labor is \$18.31 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.718(X)^{0.989}$

The supply cost consists of 95% steel items and 5% tires. Supplies include cutter bits, tires, and rockbolts.

(E) Equipment Operating Cost $(Y_E) = 0.130(X)^{1.000}$

The equipment cost consists of 85% for repair parts and 15% for fuel and lubrication. The equipment operating curve covers repair parts, fuel, and lubrication for the continuous miners, shuttle cars, and rock bolters.

ADJUSTMENT FACTOR

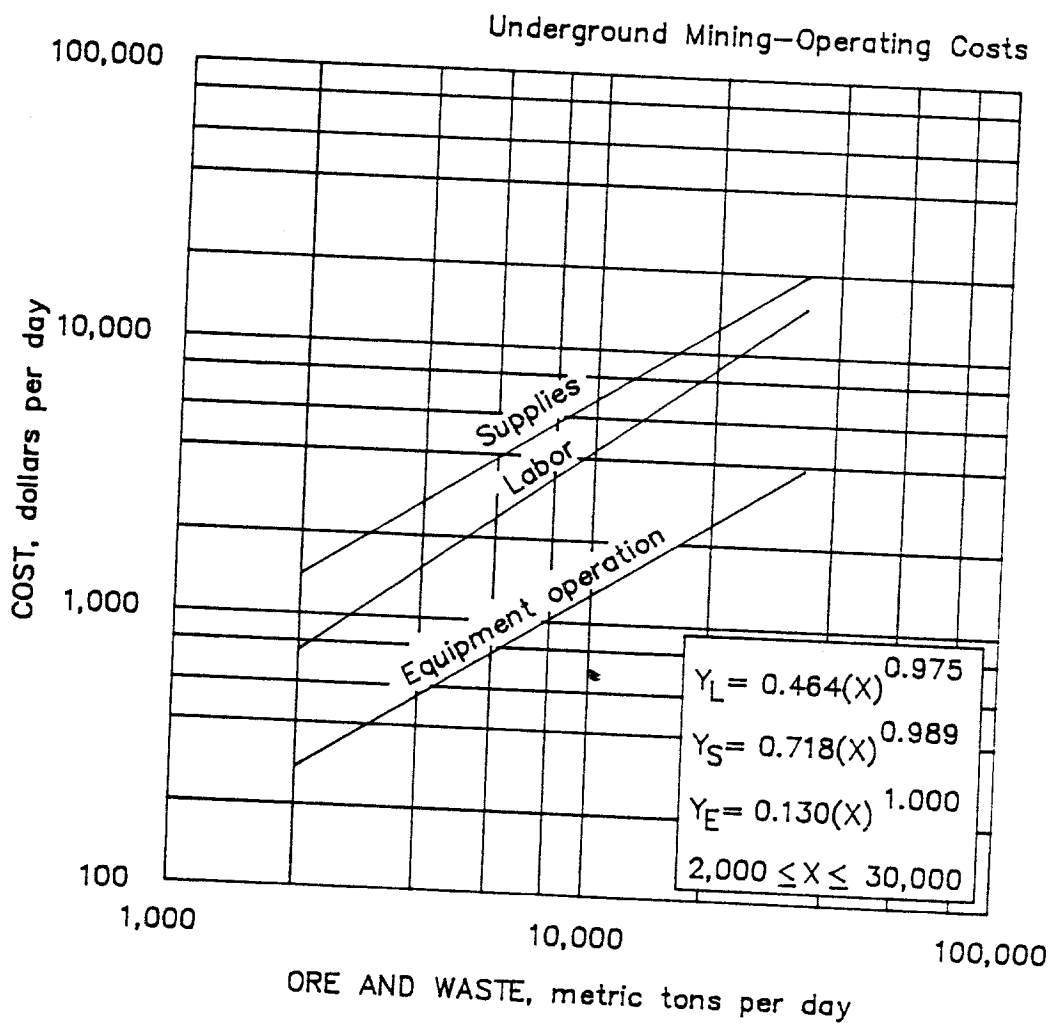
Rock Hardness Factor Continuous mining productivity is related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

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. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.3. CUT AND FILL

The cut-and-fill stope curve is based on using jacklegs for drilling and rock bolting. Costs include excavation of the ore, slushing to chutes, and sandfill operations including chute and manway extensions. Production rates vary from 6 to 12 mt per worker-shift. Only the drilling and blasting of ore during actual production are accounted for in this curve. Access drift construction and service installation are covered in the stope preparation curve. Haulage and other services are covered in separate sections.

The total daily cost per day is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 100 and 8,000 mtpd, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 49.858(X)^{0.858}$

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.....	80%	\$18.31
Helpers.....	20%	13.86

Average wage for labor is \$17.42 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 7.970(X)^{0.976}$

The supply cost consists of 26% explosives, 24% steel items, 32% timber, and 18% miscellaneous items. Supplies include drill bits and steel, powder, caps, timber, sandfill, and rockbolts.

(E) Equipment Operating Cost $(Y_E) = 0.585(X)^{0.974}$

The equipment operating cost consists of 92% for repair parts and 8% for lubrication. The equipment operating curve covers daily maintenance and repair, repair parts, and lubrication for the jacklegs, slushers, and tuggers.

ADJUSTMENT FACTORS

Rock Hardness Factor Cut-and-fill mining costs are 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):

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

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

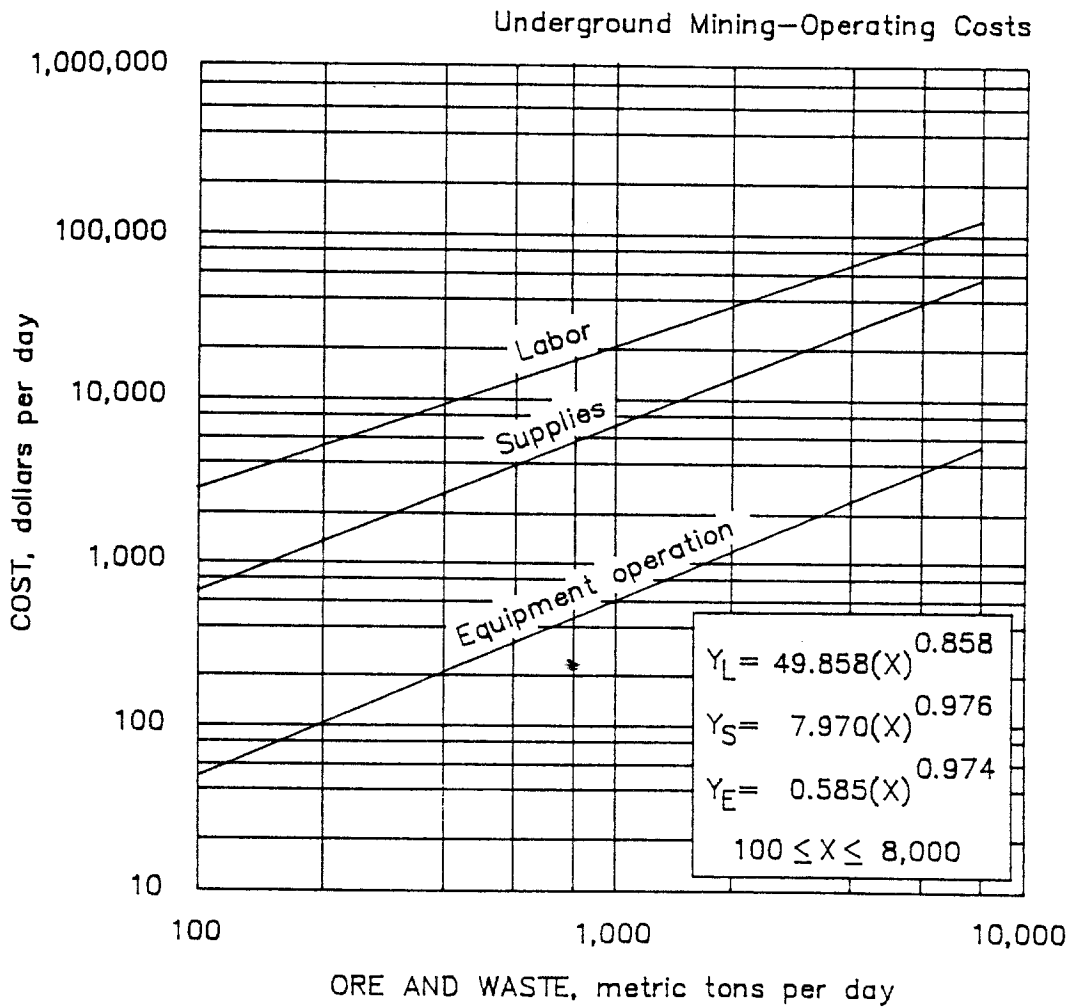
$$\text{Equipment operation factor } (F_E) = 0.716(C)^{0.033}$$

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

Width Factor The curve is based on a slope 1.83 m wide with varying lengths. For slopes from 1.0 to 6.1 m wide, multiply the costs obtained from the curves by the following factor:

$$\text{Width factor } (F_W) = 1.205(W)^{-0.315}$$

where W = width of slope, in meters.



5.2.2.3. Cut and fill

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.4. LONGHOLE

The cost curves are based on longhole stope mining using deephole ring drills for all drilling, and LHD units for drawing broken ore from a series of draw points. Costs for mining vein widths of 3.5 m and wider can be determined using these curves. Narrow or irregular veins usually do not avail themselves to longhole methods. The curves cover a production range of 350 to 10,000 mtpd. Average haul distance to a central conveyance point is estimated at 100 m. Production rates vary from 60.6 to 94.5 mt per worker-shift. Only the drilling, blasting, and drawing of the ore during actual production are accounted. Construction of drawpoints, haul-aways, sublevels, and access raises are included in the stope preparation curves.

The total daily cost per day is the sum of the three separate cost curves (labor, supplies and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 350 and 10,000 mtpd, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 4.922(X)^{0.877}$

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 (350 to 5,175 mtpd)	Large (5,175 to 10,000 mtpd)	Av salary per hour (base rate)
Miners.....	33%	44%	\$18.31
Helpers.....	33%	44%	13.86
Production loaders.....	33%	8%	16.53

Average wage for labor is \$16.15 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.764(X)^{0.973}$

The supply cost consists of 40% blasting materials, 37% drill bits and steel, 14% miscellaneous items, and 9% contingency. Supplies include drill bits, steel, ANFO, primers, caps, detonation cord, and miscellaneous items.

(E) Equipment Operating Cost $(Y_E) = 0.316(X)^{0.976}$

The equipment cost consists of 52% for maintenance and overhaul parts, 26% for tires, 17% for fuel, and 5% for lubrication. The equipment curve covers maintenance and overhaul parts, tires, fuel, and lubrication. Equipment for longhole stope mining includes LHD units, deep-hole drills, and ring drill carriers.

ADJUSTMENT FACTOR

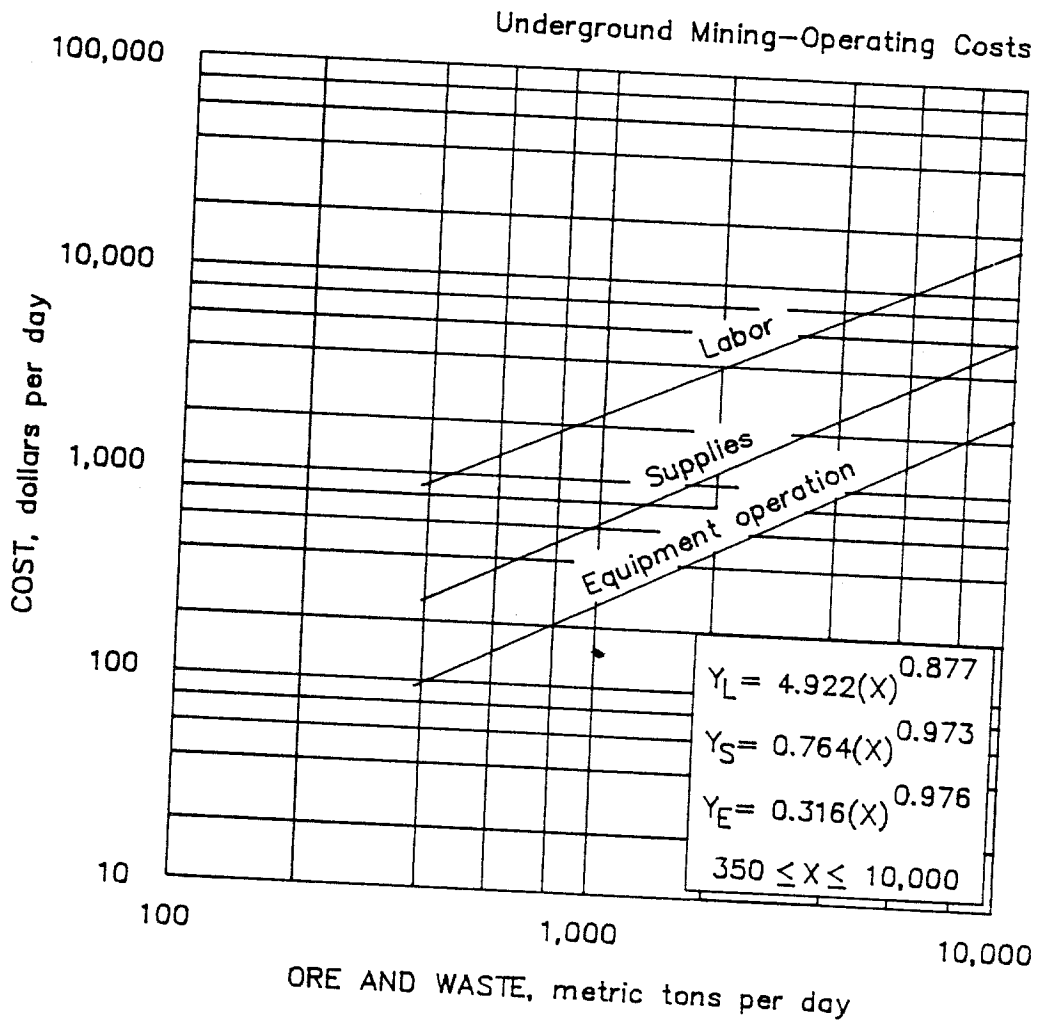
Rock Hardness Factor Longhole mining is related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

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

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

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

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



5.2.2.4. Longhole

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.5. RESUING

Resuing is a method of stoping in which the ore is broken and removed first and then the waste or vice versa; usually the one, that breaks easier is blasted first. The broken waste is left in stope as filling and the ore is broken down on flooring laid on the fill to prevent mixing of ore and waste. Resuing is applicable where the ore is not frozen to the stope walls and works best if there is considerable difference between the hardness of the ore and the wall rocks. The methods is labor intensive and is rarely practiced in North America except in very high-grade narrow vein-type deposits of higher economic values. The productivity in the stopes using a resuing method of stoping is generally low when compared with other methods of mining.

Productivity varies from 1.7 to 4.2 mt per worker shift in the stope. The average vein width considered for 20- 200- and 400-mtpd operation is 0.46 m (18 in), 0.61 m (24 in) and 0.76 m (30 in) respectively. The minimum stoping width assumed is 1.2 m (4.0 ft). Only the drawing of the ore during actual production, with partial drawing of waste when required, is accounted.

The total daily cost is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of ore per day. The curves are valid for operations between 20 and 450 mt, operating two shifts per day, 5 days a week. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

Base Curves

(L) Labor Operating Cost $(Y_L) = 219.542(X)^{0.695}$

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:

		Av salary per hour (base rate)
Miners.....	50%	\$18.31
Slusher operators.....	50%	16.53

Average wage for labor is \$17.42 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 12.157(X)^{1.050}$

The supply cost consists of 21% powder, 21% caps, 15% rockbolts, 33% timber, and 10% miscellaneous items. Supplies include powder and caps for blasting, rockbolts and timber for ground support, and miscellaneous items such as blasting wires, hangers, small tools, and material waste.

(E) Equipment Operating Cost $(Y_E) = 0.866(X)^{0.823}$

The equipment operating curve consists of 80% for maintenance and repair parts for slushers, 12% for jacklegs, and 8% for lubricants.

ADJUSTMENT FACTOR

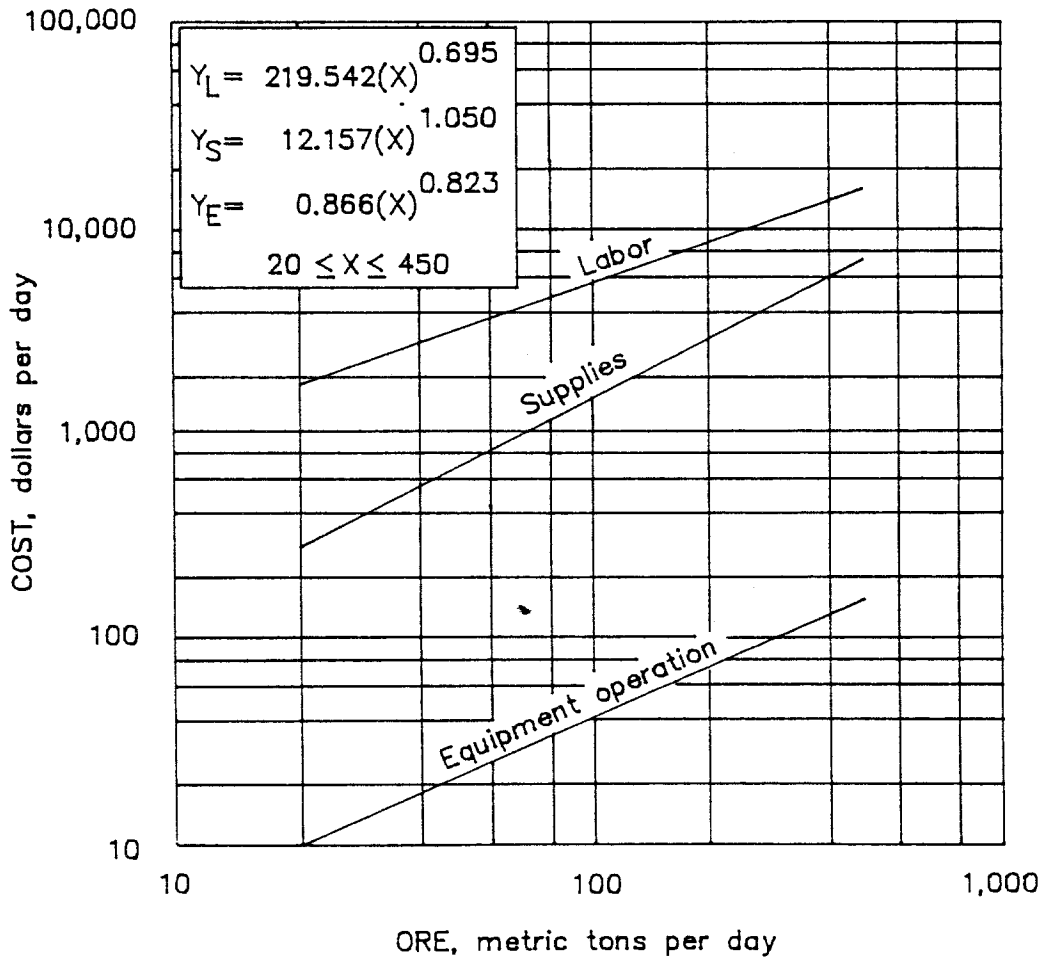
Rock Hardness Factor Resuing mining costs are related to rock hardness. If the compressive strength of the rock is known, or an estimate can be made from table A-1 in the appendix, multiply the costs obtained from the equations by the following factors (base rock strength = 31,700 psi):

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

Supplies 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.

Underground Mining—Operating Costs



5.2.2.5. Resuing

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.6. ROOM AND PILLAR
MEDIUM TO HARD ROCK

The cost curves are based on room and pillar mining using jumbo-mounted drifters for all drilling, and front-end loaders for transferring broken ore to rubber-tired haulage trucks at the face. Production rates vary from 82 to 99 mt per worker-shift. Only the drilling, blasting, and loading of the ore during actual production are accounted. Access drift construction and service installation are included in the stope preparation curves.

The total cost per day is the sum of the three separate cost curves (labor, supplies and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 1,500 and 8,000 mt, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 4.074(X)^{0.875}$

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:

	Small (1,500 to 4,750 mtpd)	Large (4,750 to 8,000 mtpd)	Av salary per hour (base rate)
Miners.....	36%	41%	\$18.31
Helpers.....	36%	41%	13.86
Utility workers.....	18%	12%	16.07
Loader operators.....	10%	6%	16.49

Average wage for labor is \$15.95 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 2.572(X)^{0.863}$

The supply cost consists of 48% blasting supplies, 26% drill bits and steel, 13% rock support materials, 8% miscellaneous items, and 5% contingency. Supplies necessary for medium to hard rock room and pillar mining include drill bits and steel, blasting agent, caps, rockbolts, and miscellaneous items.

(E) Equipment Operating Cost $(Y_E) = 0.079(X)^{0.967}$

The equipment operating cost consists of 54% for maintenance and overhaul parts, 26% for fuel, 12% for tires, and 8% for lubrication. The equipment curve covers maintenance and overhaul parts, fuel, tires, and lubrication. Equipment for medium to hard rock room and pillar mining includes jumbo-mounted drifters, front-end loaders, air leg drills, and powder buggies.

ADJUSTMENT FACTORS

Rock Hardness Factor Room and pillar mining costs are 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):

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

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

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

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

Bench Factor If the ore body is of sufficient thickness that a second pass can be bench drilled, multiply the costs obtained from the room and pillar mining equations by the following factors:

$$\text{Labor factor } (F_L) = 0.872(X)^{0.020}$$

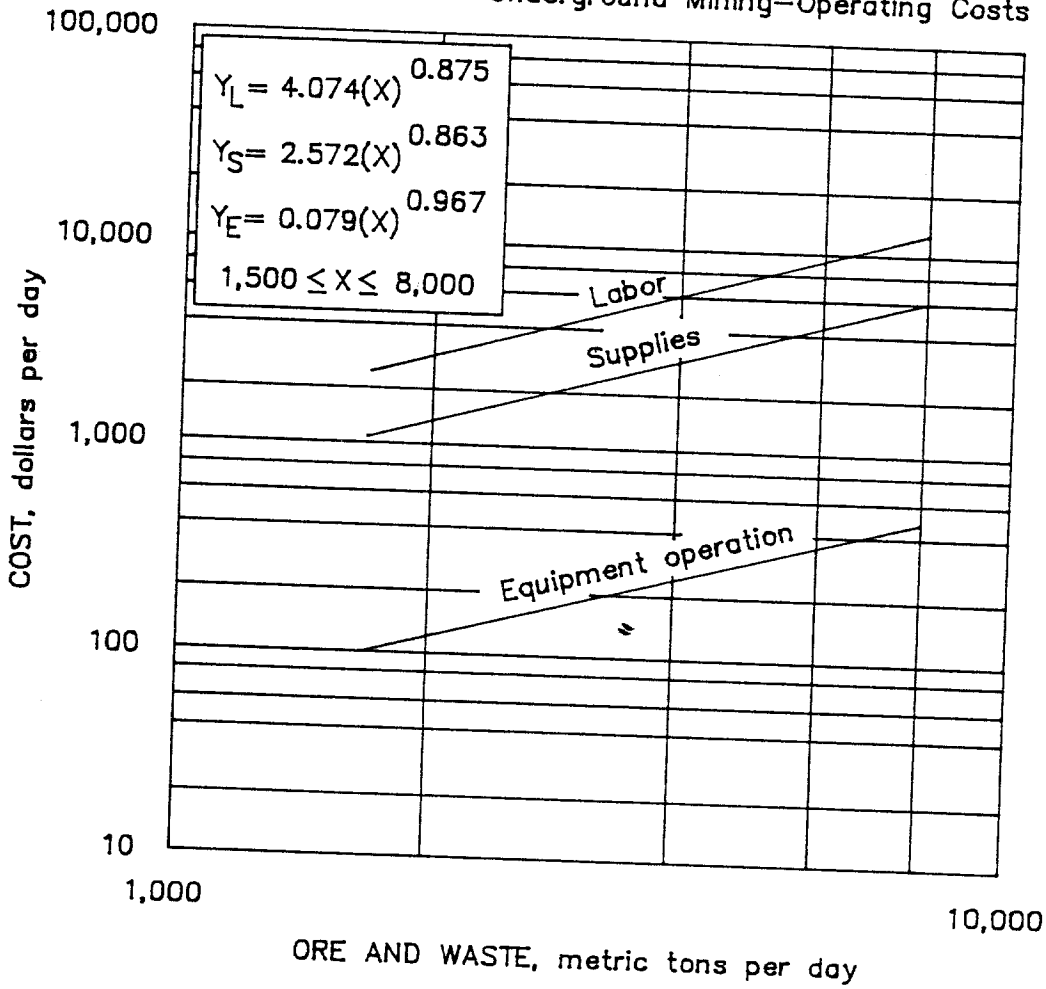
$$\text{Supply factor } (F_S) = 0.910$$

$$\text{Equipment operation factor } (F_E) = 1.498(X)^{-0.013}$$

where X = ore and waste mined, in metric tons per day.

These factors will account for the addition of airtrack drills, the labor needed for operation and repair, and the reduction of explosives associated with more efficient blasting methods. These factors are based on the assumption that 50% of all ore is extracted by bench drilling and blasting.

Underground Mining—Operating Costs



5.2.2.6. Room and pillar—medium to hard rock

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.7. ROOM AND PILLAR
NONMETALLIC SOFT ROCK

The cost curves are based on room and pillar mining using jumbo-mounted drifters for all drilling, and LHD units, or continuous loaders with shuttle cars, for handling broken ore. The average haul length to an access conveyor is estimated at 100 m. Production rates vary from 102 to 136 mt per worker-shift. Only the drilling, blasting, loading, and hauling of the ore to an access conveyor during actual production are accounted. Service and conveyor installation and access drift construction are included in the stope preparation curves.

The total cost per day is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 800 and 9,500 mtpd, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 3.186(X)^{0.894}$

The operating labor costs are distributed as follows:

Direct labor.....	87%
Maintenance labor.....	13%

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

	Small (800 to 5,150 mtpd)	Large (5,150 to 9,500 mtpd)	Av salary per hour (base rate)
Miners.....	38%	38%	\$18.27
Loader operators.....	38%	25%	13.50
Motor operators.....	-	25%	16.06
Utility workers.....	24%	12%	16.06

Average wage for labor is \$17.01 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.936(X)^{0.991}$

The supply cost consists of 26% drill bits and steel, 25% blasting supplies, 24% rock support materials, 12% electricity, 8% miscellaneous items, and 5% contingency. Supplies necessary for nonmetallic room and pillar mining include drill bits and steel, blasting agent, caps, rockbolts, electricity, and miscellaneous items.

(E) Equipment Operating Cost $(Y_E) = 2.159(X)^{0.723}$

The equipment operating cost consists of 68% for maintenance and overhaul parts, 18% for tires, 11% for lubrication, and 3% for fuel. The equipment curve covers

maintenance and overhaul parts, fuel, tires, and lubrication. Equipment for nonmetallic room and pillar mining includes jumbo-mounted drifters, roof bolters, powder buggies, undercutters, LHD's or continuous loaders with shuttle cars, and transformers.

ADJUSTMENT FACTOR

Rock Hardness Factor Room and pillar mining costs are 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):

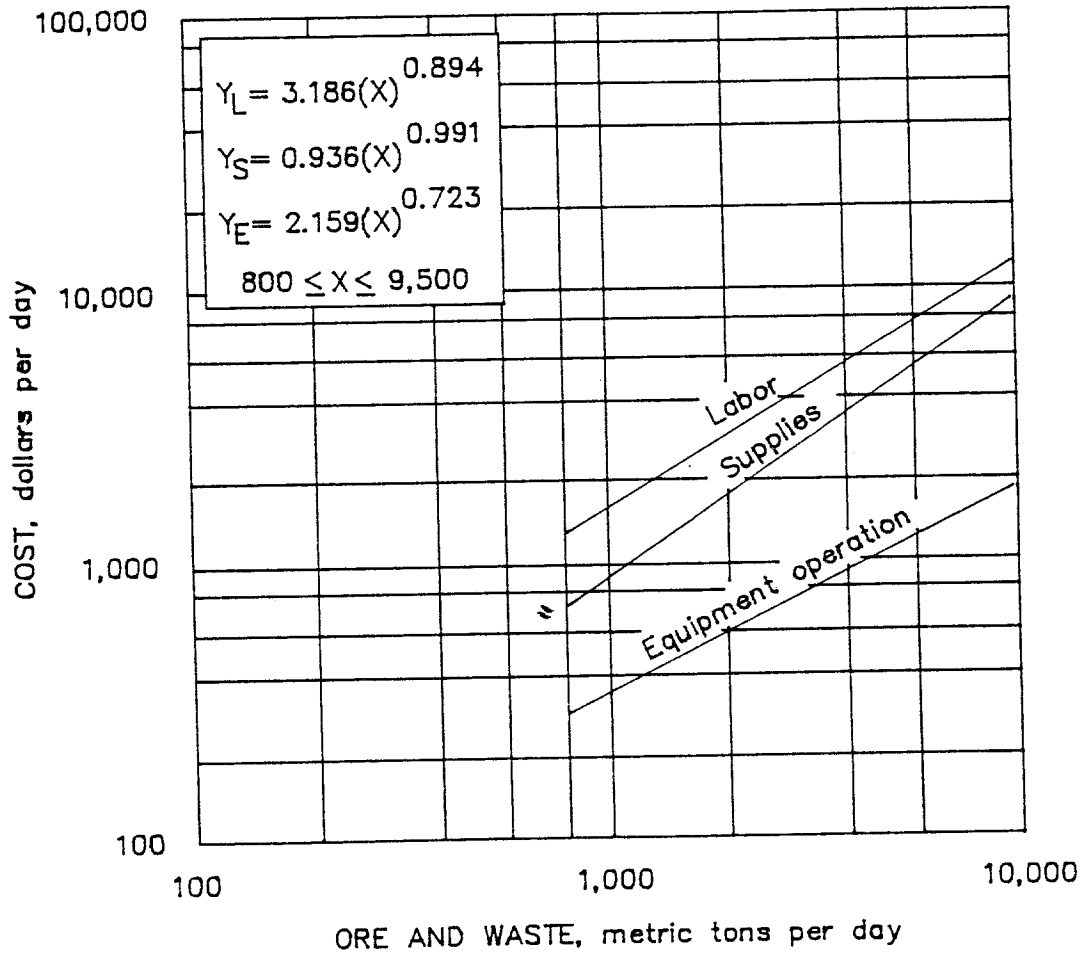
$$\text{Labor factor } (F_L) = 0.388(C)^{0.093}$$

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

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

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

Underground Mining—Operating Costs



5.2.2.7. Room and pillar—nonmetallic soft rock

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.8. SHRINKAGE

The shrinkage stope curve is based on using stopers for drilling and jacklegs for rock bolting. Production rates vary from 3 to 10 mt per worker-shift. Only the drilling and blasting of ore during actual production are accounted for in this curve. Access drift construction and service installation are covered in the stope preparation curve. Haulage and other services are covered in separate sections.

The total cost per day is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 100 and 4,000 mt, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 39.395(X)0.895$

The operating labor costs are distributed as follows:

Direct labor.....	99.8%
Maintenance labor.....	0.2%

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.....	67%	\$18.31
Helpers.....	33%	13.86

Average wage for labor is \$16.84 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 3.549(X)0.987$

The supply cost consists of 25% explosives, 48% steel items, 22% timber, and 5% miscellaneous items. Supplies include drill bits and steel, powder, caps, timber, and rockbolts.

(E) Equipment Operating Cost $(Y_E) = 0.086(X)0.894$

The equipment operating cost consists of 93% for repair parts and 7% for lubrication. The equipment operating curve covers daily maintenance and repair, repair parts, and lubrication for the stopers and jacklegs.

ADJUSTMENT FACTORS

Rock Hardness Factor Shrinkage mining costs are 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):

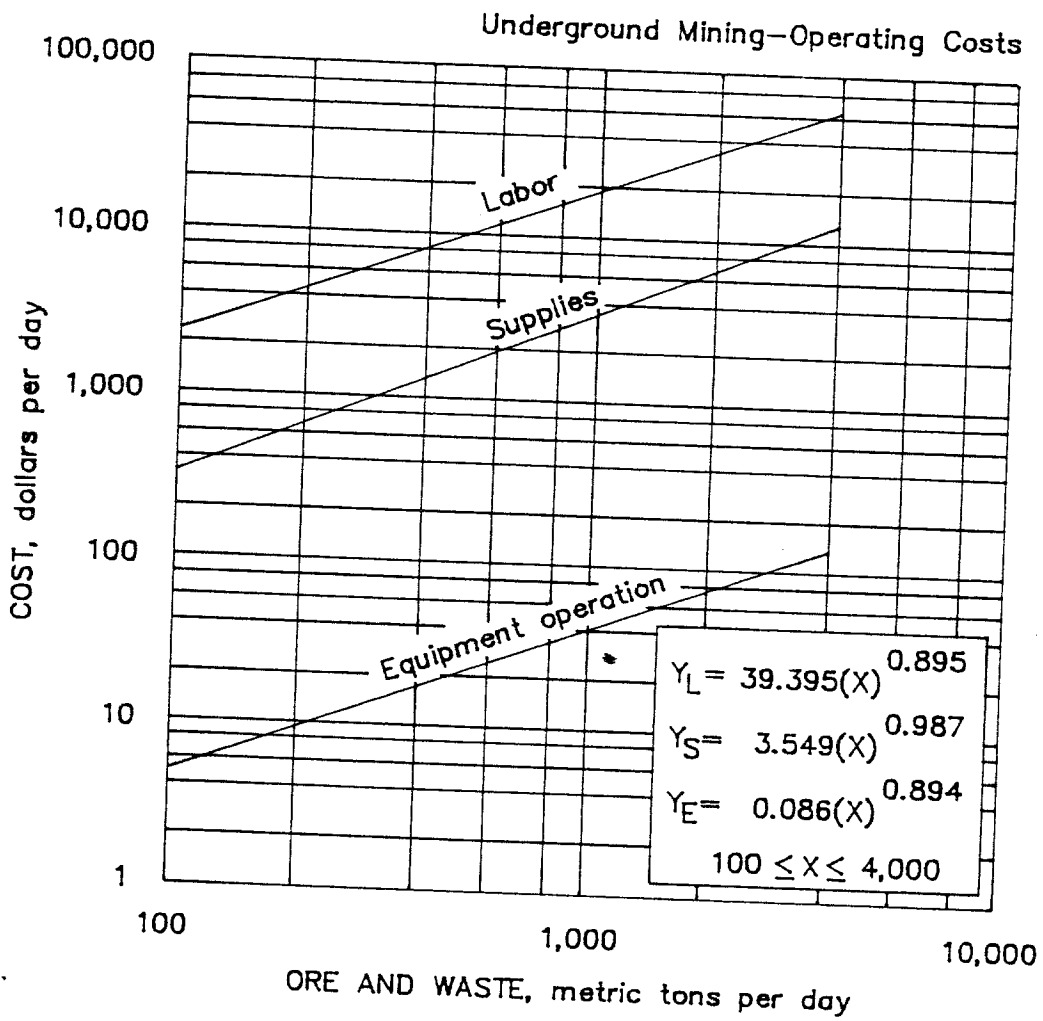
Labor factor $(F_L) = 0.399(C)^{0.091}$

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.

Width Factor The curve is based on a slope 1.83 m wide with varying lengths. For slopes from 1.0 to 6.1 m wide, multiply the costs obtained from the curves by the following factor:

Width factor $(F_W) = 1.353(W)^{-0.500}$
where W = slope width, in meters.



5.2.2.8. Shrinkage

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.9. SQUARE SET

The square set stope curve is based on using jacklegs for drilling and rock bolting. Costs include excavation of the ore, slushing to chutes, and timber installation including chute and manway extensions. Production rates vary from 4 to 8 mt per worker-shift. Only the drilling and blasting of ore during actual production are accounted for in this curve. Access drift construction and service installation are covered in the stope preparation curve. Haulage and other services are covered in separate sections.

The total cost per day is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 20 and 200 mt, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 60.332(X)^{0.839}$
 The operating labor costs are distributed as follows:

Direct labor.....	99%
Maintenance labor.....	1%

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.....	100%	\$18.31

Average wage for labor is \$18.31 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 13.246(X)^{0.890}$
 The supply cost consists of 22% explosives, 13% steel items, 59% timber, and 6% miscellaneous items. Supplies include drill bits and steel, powder, caps, timber, and rockbolts.

(E) Equipment Operating Cost $(Y_E) = 0.750(X)^{0.902}$
 The equipment operating cost consists of 92% for repair parts and 8% for lubrication. The equipment operating curve covers daily maintenance and repair, repair parts, and lubrication for the jacklegs, slushers, and tuggers.

ADJUSTMENT FACTORS

Rock Hardness Factor Square set mining costs are 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):

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

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

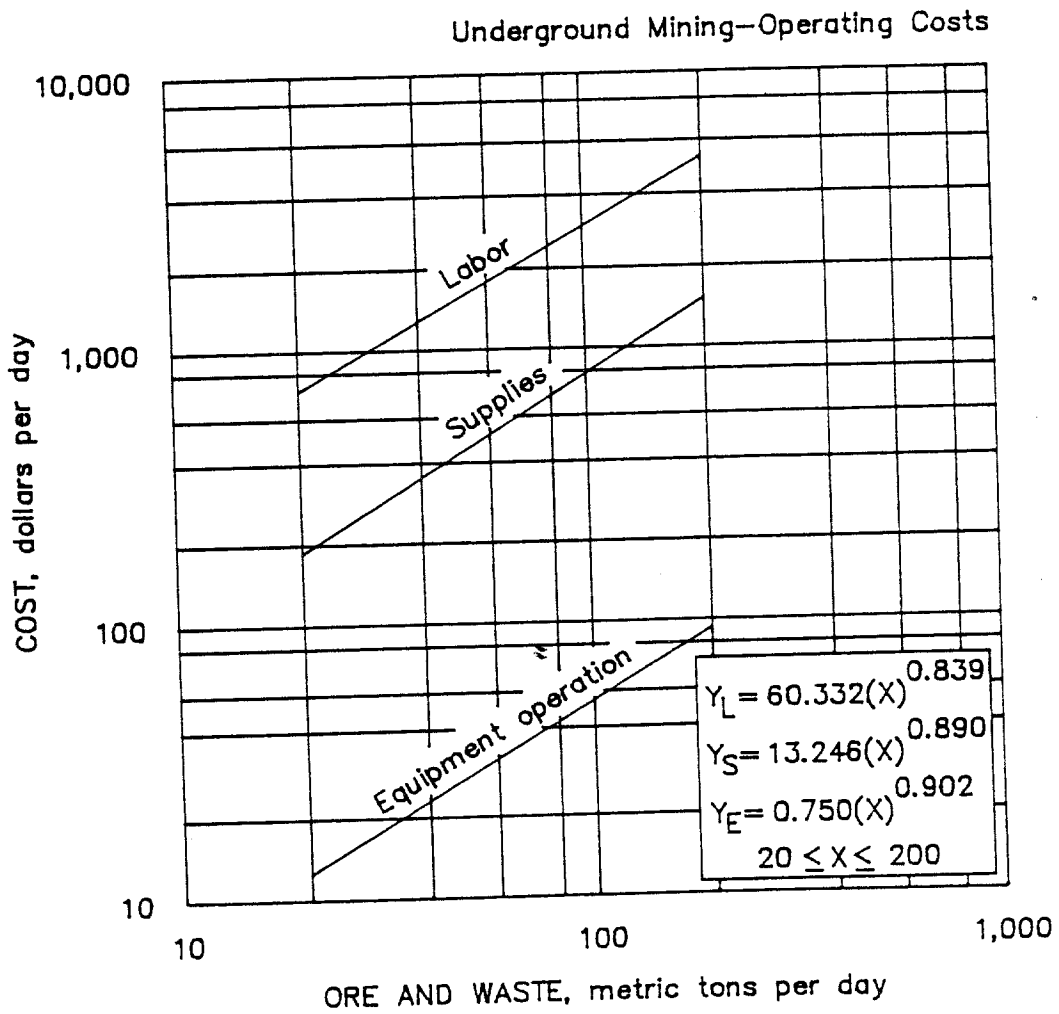
$$\text{Equipment operation factor } (F_E) = 0.716(C)^{0.033}$$

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

Width Factor The curve is based on a slope 7.2 m wide with varying lengths. For slopes from 1.0 to 7.2 m wide, multiply each curve value by the following factor:

$$\text{Width factor } (F_W) = 1.50(W)^{-0.205}$$

where W = slope width, in meters.



5.2.2.9. Square set

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.2. MINING

5.2.2.10. VERTICAL CRATER RETREAT

The cost curves are based on VCR stope mining using down-hole drills for all drilling, and LHD units for drawing broken ore. The curves apply to any mining system in which large-diameter blastholes are loaded from the top sill, and ore is blasted into an undercut. This includes vertical crater retreat, vertical retreat mining, and end slicing to a drop raise. Average haul distance to a central conveyance point (truck loading station, ore pass, or underground crushing station) is estimated at 200 m. Production rates vary from 107 to 200 mt per worker-shift. Only the drilling, blasting, and drawing of the ore during actual production are accounted. Construction of drawpoints, top sill cuts, bottom sill cuts, and access drifts are included in the stope preparation curves.

The total cost per day is the sum of the three separate cost curves (labor, supplies and equipment operation) based on a production rate (X), in metric tons of ore and waste per day. The curves are valid for operations between 650 and 4,000 mt, operating two shifts per day. Cost per metric ton of ore is calculated by dividing the total cost per day by the metric tons of ore produced per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 23.075(X)^{0.595}$

The operating labor costs are distributed as follows:

Direct labor.....	87%
Maintenance labor.....	13%

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

	Small (650 to 2,975 mtpd)	Large (2,975 to 4,000 mtpd)	Av salary per hour (base rate)
Drillers (miners).....	14%	21%	\$18.27
Helpers.....	14%	21%	13.82
Blasters (miners).....	29%	42%	18.35
LHD operators.....	29%	11%	16.50
Lead blaster.....	14%	5%	15.11

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

(S) Supply Operating Cost $(Y_S) = 2.152(X)^{0.947}$

The supply cost consists of 69% blasting supplies, 13% drill bits and steel, 9% miscellaneous items, and 9% contingency. Supplies necessary for VCR mining include drill bits, drill steel, blasting agent, primers, caps, detonation cord, caristrap, timber, and miscellaneous items.

- (E) Equipment Operating Cost $(Y_E) = 1.502(X)^{0.792}$
 The equipment operating cost consists of 44% for maintenance and overhaul parts, 33% for fuel, 16% for tires, and 7% for lubrication. The equipment curve covers maintenance and overhaul parts, fuel, tires, and lubrication. Equipment for VCR stope mining includes down-hole drills, air track drill carriers, booster compressors, LHD units, and bit grinders.

ADJUSTMENT FACTORS

Rock Hardness Factor VCR productivity is 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):

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

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

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

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

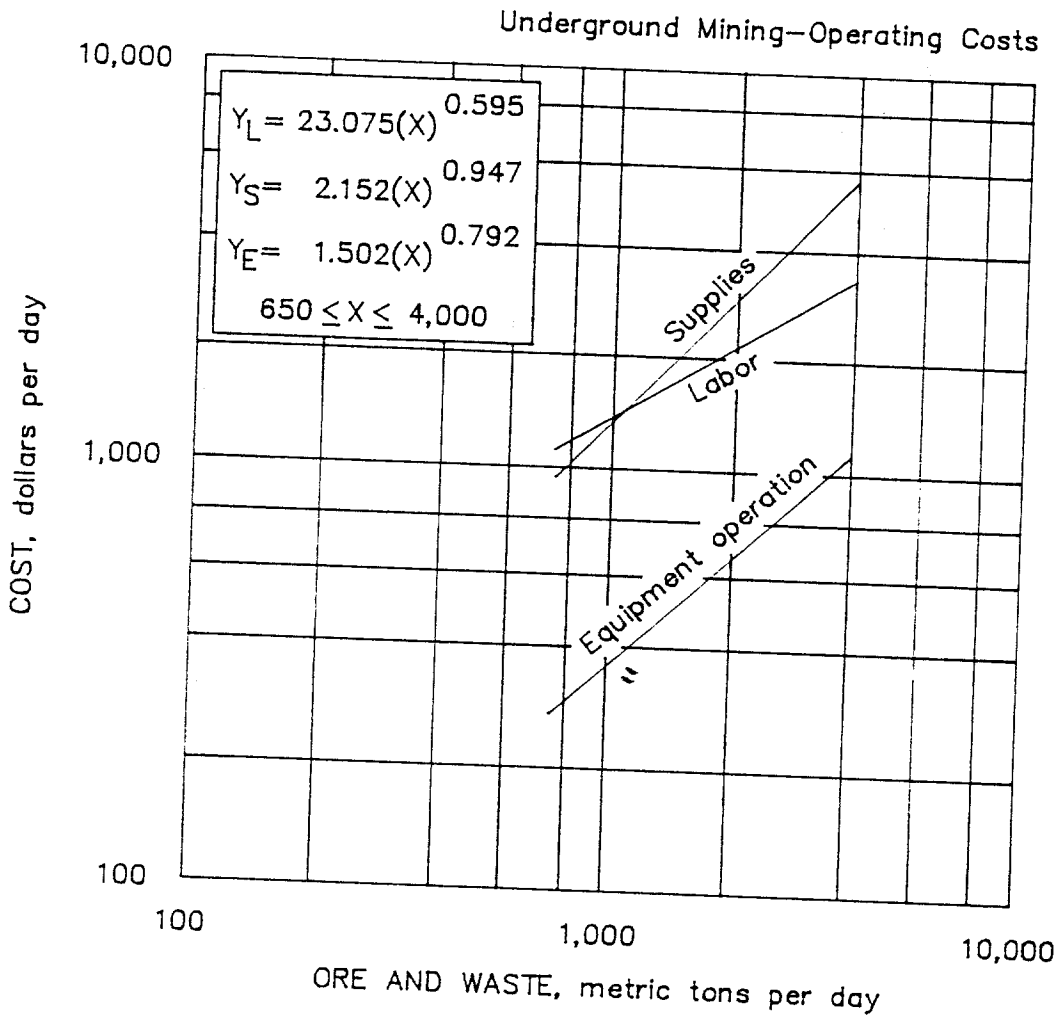
Backfilled Stope Factor If stopes are to be backfilled, multiply the labor and supply costs obtained from the VCR stope mining curves by the following factors:

$$\text{Labor factor } (F_L) = 0.863(X)^{0.030}$$

$$\text{Supply factor } (F_S) = 1.635(X)^{0.027}$$

where X = metric tons of ore and waste mined per day.

These factors will account for the additional labor needed for backfill operations, and the material needed for fill.



5.2.2.10. Vertical crater retreat