Cost Comparison of Planer Mining and Open-Stope Mining of Phosphate Rock

George Krempasky

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A Thesis
Submitted To
Professor K. S. Stout

COST COMPARISON OF PLANER MINING
AND OPEN-STOPE MINING OF PHOSPHATE ROCK

by
George Krempasky

May 13, 1957
Montana School of Mines
Mining 68
Mining Engineering

A Thesis
Submitted To
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COST COMPARISON OF PLANER MINING
AND OPEN-STOPE MINING OF PHOSPHATE ROCK

by
George Krempasky

May 13, 1954
Montana School of Mines
Professor K. S. Stout  
Mining Department  
Montana School of Mines  
Butte, Montana

Dear Professor Stout:

I am submitting my thesis on a Cost Comparison of Planer Mining and Open-Stope Mining of Phosphate according to the instructions given to me during the semester.

The thesis covers the estimated cost of development and cost extraction of phosphate by the two methods. While it was thought that a resume of a newly constructed planer would also be considered; the failure of the manufacture to deliver the planer on schedule prevented this.

I hope that this paper will enlighten who ever reads it on the feasibility of such a mining method.

Respectfully submitted,

George T. Krempasky.
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<th>Page</th>
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INTRODUCTION

This paper outlines and describes a proposed mining method and its costs. The object of the paper is to evaluate a low-cost, maximum recovery, underground mining method for mining Western phosphate rock as compared to an open-stope system.

The spectacular growth of the phosphate rock industry in the United States, which began with a production of 2 long tons of $P_2O_5$ content in South Carolina, has expanded from about 450,000 long tons of $P_2O_5$ content in 1900 to nearly 4,000,000 long tons of $P_2O_5$ content in 1952. 1/

With the growth of the phosphate industry in the United States, the Bureau of Mines has done preliminary work on the development of a continuous mining machine, called a planer, which is adaptable to various types of underground deposits. It is the belief of the author that if the eventual development of the planer is accomplished the overall recovery of mineable phosphate rock in the Western mines will increase. Thus, the present methods of mining phosphate rock, room and pillar, open-stopes with pillars and stulls, can be abandoned and a more revolutionary method can be used.

This method in its simplest form would be the development of the mineable bed to its end lines. This can be done by drifting in the footwall and raising at the end line. This would result in a minimum amount of development work prior to mining with the planer.


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-l-
Therefore, while this problem is considered as a hypothetical situation much of the information used is taken from an operating mine.

DESCRIPTION OF THE DEPOSIT

The Phosphoria formation in Powell County varies in thickness from 35 feet to 50 feet, and contains a bed of phosphate rock that varies from 2.5 feet to 5.0 feet thick. The phosphate bed is overlain by 12 to 30 feet of cherty-quartzite and underlain by a hard quartzitic sandstone. It can be said that the present mining method is governed by the thickness of the cherty-quartzite hanging wall.

The phosphate bed has been deformed considerably by folding in this area. It is carried to the surface by several anticlines and lowered to considerable depths by some of the synclines. The structural features affecting the mining operations are the anticlines, locally called Garrison anticline, and an adjoining syncline and a limb of a second anticline on the east. The axis of the folding strikes in a NW-SE direction.

The phosphate bed is made up of a number of bands, which varies in thickness and in hardness. The bands are separated by distinct partings usually resulting from a thin phosphatic clay seam. The bed also possesses distinct jointing perpendicular to the bedding planes (fig.1).

The stratigraphic section of the Phosphoria formation shows that the Quadrant underlies the Phosphoria and the Ellis and Kootenai overlay. The
- Cherty quartzite.
- Clay seam.
- Hard, massive, somewhat siliceous, phosphate rock, some jointing.

- Thin-bedded, medium-hard, phosphate rock interbanded with clay seams.

- Clay seam (drill seam).
- Hard, massive, phosphate rock, well jointed.
- Phosphatic clay (blue clay).
- Hard, somewhat siliceous, phosphate rock, some jointing.
- Quartzizite.

Figure 1.—Typical section of phosphate bed, Anderson mine, Powell County, Montana.
Ellis and Kootenai formations in this area are primarily shales and sandstones, while the Quadrant is characterized by quartzitic sandstones (fig.2).

HISTORY

Phosphate ore probably was first recognized in the West in or about 1889. While the ore was discovered at this date, no production resulted from the Western Fields until 1906, and since that date underground operations operated sporadically. The enormous demand for phosphate caused wide interest; thus resulting in open-pit mining in some of the region.

In 1920 Anaconda Copper Mining Company opened and still operates an underground operation near Soda Springs, in the southeastern part of Idaho. It was in 1930 that Montana Phosphate Products Company started underground operations near Garrison, Montana and has remained a steady producer. In 1950 Victor Chemical Works developed an underground operation near Maiden rock, Montana and has continued ever since.

While the major concern of this paper is the vast reserves that must be mined by an economically efficient underground mining method; we must realize that within the past 15 years strip-mining or open-pit mining has invaded the phosphate field.

San Francisco Chemical Company, probably the oldest company in the Western Field, started strip-mining near Montpelier, Idaho in 1945 and
Figure 2.—Stratigraphic section, Anderson mine, Powell County, Montana.
later on advanced a strip-mining operation near Sage Junction, Wyoming.

In 1946 J.R. Simplot began a strip-mining operation near Fort Hall, Montana and in recent years has started an open-pit mining operation near Monida, Montana; while Montana Phosphate Products Company in conjunction with Utah Construction Company have undertaken an open-pit project near its Garrison mine.

Development of planers for mining is a direct result of observations made in Germany in 1945. A history of planer development was published 2/ and research was undertaken by the United States Bureau of Mines to determine if planer mining could be used in the coal fields of the Eastern part of the United States.

It was then considered that the applicability of planer mining to phosphate should be determined. In 1954 a planer patterned after a pneumatic coal planer was built by the Bureau of Mines in Spokane, Washington. The original planer contained 4 paving breakers mounted on a vertical plate installed at an angle to the line of travel of the machine(fig.3).

The planer was modified after the first series of test to incorporate the findings resulting from the initial test. An additional breaker was mounted on a pneumatic ram, which raises and lowers the breaker to the maximum width of the mineable bed (fig.4).

Figure 4 - Original planer with modifications
At the present time a planer designed and constructed by an engineering firm is being readied for its initial test. This planer will incorporate some of the changes recommended by the engineers, who conducted the initial tests. The new planer will weigh approximately 8500 lbs and will employ larger tools and larger breakers. It is believed that this testing period will prove that phosphate can be mined by a planer; therefore, requiring the designing of a mining method for planer mining.

MINING METHOD

No outstanding developments in mining technology were reported during the past few years, but many improvements can be noted. One of these improvements noted is the development of a phosphate planer by the United States Bureau of Mines and the Montana Phosphate Products Company.

The various mining methods used in mining phosphate have been established for many years. The methods have generally been improved and modified to fit new equipment and new procedures. Mining practices continue to improve. This can be illustrated by the increasing use of rock bolting, cut-and-fill stoping replacing the expensive square-set system, and the refinements in block-caving over the past few years in the metal mines.

The continuous miner, phosphate planer, under ideal conditions would bring about a change in the method of mining phosphate rock. This method would result in a long-wall type of mining method, with the planer cutting the entire face from level to level. It is possible that with the use of
recoverable stalls 100 percent recovery of the mineable ore can be obtained. The present method, open-stope with pillar and stalls or props, used by many of the underground producers, recovers approximately 70 percent of the mineable rock that has been made accessible by the development work. The cost of development for the present mining method is approximately $1.689 per ton of ore mined; while the cost of development for long-wall mining with the planer would be approximately $0.588 per ton of ore mined. The cost of extraction of a ton of ore mined by the present mining method is about $0.8868, excluding fixed and transportation charges. The estimated cost of mining by the planer under the same conditions would be about $0.634 per ton of ore mined.

It is noted that while the initial cost to develop a larger block of ore would require a larger outlay of capital at the beginning; the overall return on the invested dollar would be greater. The major factors to be considered in a change over from open-stope mining to mining with the planer are: is the proposed method cheaper, is it safer, and does the method provide a greater recovery rate.

In the development of a present operating mine to long-wall mining with the planer, it would be necessary to choose the most adaptable system. Plates I and II illustrate three methods that can be used to develop a dipping bed. Plate I shows an idealized section for long-wall mining using both slusher loading and mucking machine loading. While both methods are somewhat similar the drawings show that it would be necessary to do more
development work to ready a place for mining with the planer by the slusher type method then any of the other two. A minimum amount of development work would be needed if the method sketched on Plate II is used.

In the three types illustrated it would be necessary to develop the block with a drift, the entire length of the block, and to drive a raise at the end lines from level to level. The methods illustrated on Plate I would require additional development work such as: driving slusher drifts the length of the drift and draw raises from the main haulage level to the slusher drifts. The third method of mucking directly from the sill of the haulage level would require the minimum amount of development. This would allow the muck to fall directly to the haulage level and to be mucked by the mucking machine. A cost comparison of the third method with that of present open-stope method has been made and is included in the appendix.

The discussion of the underground transportation is not undertaken; because it is believed that the transportation costs under all methods would be similar.

Ventilation of most of the mines in the phosphate fields are a result of natural ventilation with the aid of small fans in the dead end areas. As the planer mining method would not have any dead end it is believed that ventilation cost for this system of mining would be much cheaper.
SUMMARY AND CONCLUSION

The growth of the phosphate industry in the United States has brought extensive research in a continuous miner for phosphate. This machine called a planer was tested at the Anderson Mine near Garrison, Montana. Production figures obtained from the test show that the machine can compete with the standard mining practices with regards to cost, safety and has a greater recovery rate then the standard practices.

The comparison of cost to a proposed planer mining method is brought out in the appendix of this report. In the cost for development of an open-stope mining system it was found that this method would require the expenditure of $1.689 per ton of ore extracted as compared to $0.589 for development costs for a proposed planer mining method.

In the comparison of cost per ton of ore extracted; the rate of 100 tons per shift by open-stope mining can be considered to be the best performance that can be obtained; while the rate of 26.6 tons per operating hour for the planer is considered below the average that can be obtained by the planer. During a testing day at the mine a production of 175 tons was obtained in less then 3 hours of operating time, an average of 58 tons per operating hour. The possibility of an increase in the rate of extraction will undoubtedly occur when the new planer is readied for its testing period. This testing period was to start May 7, 1957, but due to delays in fabrication of the machine it has been set back at least ten days.
In conclusion it can be said that a proposed mining system for the planer will be cheaper; both in development costs and in mining costs. The planer mining method will also be cheaper in ventilation cost; it also will be safer; it also increase the rate of recovery within the mine.
APPENDIX

Cost distribution (disregarding fixed costs) for mining and developing an area for planer mining

Estimated 1500 feet of drifting necessary to develop the block.

Estimated rate of advance 4.0 feet per day.

Estimated time of completion for drifting 1500 feet-375 days say 18 months.

1. Labor and Supervision:

<table>
<thead>
<tr>
<th>Description</th>
<th>Rate</th>
<th>Duration</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 miners at $17.00 per day</td>
<td>375 days</td>
<td></td>
<td>$19,125.00</td>
</tr>
<tr>
<td>1 motorman at $17.00 per day</td>
<td></td>
<td></td>
<td>6,375.00</td>
</tr>
<tr>
<td>1 hoist man at $18.75 per day</td>
<td></td>
<td></td>
<td>7,021.25</td>
</tr>
<tr>
<td>1 topman at $16.00 per day</td>
<td></td>
<td></td>
<td>6,000.00</td>
</tr>
<tr>
<td>1 supervisor at $600.00 per month</td>
<td>18 months</td>
<td></td>
<td>10,800.00</td>
</tr>
</tbody>
</table>

$49,321.25

2. Operating equipment and supplies:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>fuse 90,000 feet at $1.37 per 100 ft</td>
<td>$1,233.00</td>
</tr>
<tr>
<td>caps 9,000 at $2.30 per 100</td>
<td>207.00</td>
</tr>
<tr>
<td>explosives 25,000 lbs at $22.40 per cwt</td>
<td>5,600.00</td>
</tr>
<tr>
<td>100 carbide bits at $15.60 each</td>
<td>1,560.00</td>
</tr>
<tr>
<td>100 6-ft length drill rods at $9.10 each</td>
<td>910.00</td>
</tr>
<tr>
<td>2-50 foot 1/2&quot; water hose at 28.80 each</td>
<td>57.60</td>
</tr>
<tr>
<td>2-50 foot 3/4&quot; air hose at $34.40 each</td>
<td>68.80</td>
</tr>
<tr>
<td>4-oil liners at $21.00 each</td>
<td>84.00</td>
</tr>
</tbody>
</table>

Track

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000 feet of rails at $0.8958 per foot</td>
<td>$2,687.40</td>
</tr>
</tbody>
</table>
156 pairs splice bars at $0.61 per pair $ 95.16
600 lbs of track spikes at $15.65 per cwt 93.90
750 ties at $0.35 per tie 262.50
750 track bolts-175 lbs- at $24.95 per cwt 112.50

Pipe:
1500 feet of 2" pipe at $0.4365 per foot 654.75
1500 feet of 1" pipe at $0.21 per foot 315.00
pipe fittings at 20% of $969.75 193.95

Ventitube:
1500 feet 8" ventitube at $0.70 per foot $ 1,050.00

Power and fuel:
power consumption approximately $1.50 per foot advance
say $6.00 per day 2,550.00

$6,015.16

3. Operating equipment to be used:

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Depreciation/mo</th>
<th>Months used</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>mine cars</td>
<td>$ 15.00</td>
<td>18</td>
<td>$ 270.00</td>
</tr>
<tr>
<td>1</td>
<td>Coppus fan</td>
<td>5.00</td>
<td>&quot;</td>
<td>90.00</td>
</tr>
<tr>
<td>1</td>
<td>compressor</td>
<td>100.00</td>
<td>&quot;</td>
<td>1800.00</td>
</tr>
<tr>
<td>10</td>
<td>mine lamps</td>
<td>5.00</td>
<td>&quot;</td>
<td>90.00</td>
</tr>
<tr>
<td>2</td>
<td>drills with legs</td>
<td>18.00</td>
<td>&quot;</td>
<td>324.00</td>
</tr>
<tr>
<td>1</td>
<td>loader</td>
<td>42.00</td>
<td>&quot;</td>
<td>756.00</td>
</tr>
<tr>
<td>1</td>
<td>motor</td>
<td>50.00</td>
<td>&quot;</td>
<td>900.00</td>
</tr>
<tr>
<td>2</td>
<td>battries</td>
<td>25.00</td>
<td>&quot;</td>
<td>450.00</td>
</tr>
</tbody>
</table>

$4,680.00
4. Miscellaneous, unemployment insurance. F. I. C. etc.,

approximately 15% of $49,321.25

Totals:

Labor and Supervision $49,321.25
Operating equipment and supplies 16,735.16
Operating equipment to be used 4,460.00
Miscellaneous 7,398.19

$77,135.00

Cost per foot of drifiting excluding fixed costs:

\[
\frac{77135.00}{1500} = \$51.42
\]
Cost distribution (disregarding fixed costs) for raising in ore.
Required: one for planer mining; at least 7 for open-stope mining.
Estimated length of raise along the dip 300 feet.
Estimated rate of advance 4.5 feet per day.
Estimated time of completion for 300 feet of raise 75 days say 3.75 months

1. Labor and Supervision:

<table>
<thead>
<tr>
<th>3 miners at $17.00 per day</th>
<th>75 days</th>
<th>$3,825.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/6 supervision at $600.00 per month</td>
<td>3.75 mo.</td>
<td>2,250.00</td>
</tr>
<tr>
<td>1 motorman at $17.00 per day</td>
<td>75 days</td>
<td>1,275.00</td>
</tr>
</tbody>
</table>

$7,350.00

2. Operating equipment and supplies:

| fuse 7200 feet at $1.37 per 100 feet | $98.64 |
| caps 720 at $2.27 per 100 | 16.56 |
| explosives 3000 lbs at $22.40 per cwt | 672.00 |
| 20 carbide bits at $15.60 each | 312.00 |
| 20 drill rods 6-ft length at $9.10 each | 182.00 |
| 2-50 foot 1/2" water hose at $28.80 each | 57.60 |
| 2-50 foot 3/4" air hose at $34.40 each | 68.80 |
| 1 oil liner at $21.00 | 21.00 |
| 200 feet of ventitube at $0.70 per foot | 140.00 |
| power approximately $3.00 per day | 225.00 |
| 250 feet 2" pipe at $0.4365 per foot | 109.13 |
| 250 feet 1" pipe at $0.21 per foot | 52.50 |

$1,955.23
3. Operating equipment to be used:

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Depreciation/mo.</th>
<th>Months used</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>mine cars</td>
<td>$ 15.00</td>
<td>3.75</td>
<td>$ 56.25</td>
</tr>
<tr>
<td>1</td>
<td>Coppus fan</td>
<td>5.00</td>
<td>&quot;</td>
<td>18.75</td>
</tr>
<tr>
<td>1</td>
<td>compressor</td>
<td>100.00</td>
<td>&quot;</td>
<td>375.00</td>
</tr>
<tr>
<td>4</td>
<td>mine lamps</td>
<td>2.50</td>
<td>&quot;</td>
<td>9.38</td>
</tr>
<tr>
<td>1</td>
<td>drill</td>
<td>18.50</td>
<td>&quot;</td>
<td>67.50</td>
</tr>
<tr>
<td>1</td>
<td>hoist(slusher)</td>
<td>29.30</td>
<td>&quot;</td>
<td>109.88</td>
</tr>
<tr>
<td>1</td>
<td>bucket</td>
<td>5.00</td>
<td>&quot;</td>
<td>18.75</td>
</tr>
<tr>
<td>1</td>
<td>motor</td>
<td>50.00</td>
<td>.64</td>
<td>31.25</td>
</tr>
<tr>
<td>2</td>
<td>batteries</td>
<td>25.00</td>
<td>&quot;</td>
<td>15.68</td>
</tr>
</tbody>
</table>

4. Miscellaneous, unemployment insurance, F. I. C. etc.,
approximately 15% of 7350.00

$1,102.50

Totals:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor and Supervision</td>
<td>$ 7,350.00</td>
</tr>
<tr>
<td>Operating equipment and supplies</td>
<td>1,955.23</td>
</tr>
<tr>
<td>Operating equipment to be used</td>
<td>702.44</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1,102.40</td>
</tr>
</tbody>
</table>

$11,660.17

Cost per foot of raise excluding fixed costs:

\[
\frac{11060.17}{300} = \$ 36.87
\]
Approximate tonnage left in pillars by open-stope mining method.

Total tonnage in the block:
\[
\frac{1500 \times 300 \times 4.5}{13.5} = \text{length x width x thickness} = 150,000\text{ cu.ft./ton}
\]

25 foot sill pillar at the top of the stope:
\[
\frac{25 \times 1500 \times 4.5}{13.5} = 12,500
\]

25 foot pillar left at the bottom of the block:
\[
\frac{25 \times 1500 \times 4.5}{13.5} = 12,500
\]

22 12-foot pillars between stopes:
\[
\frac{12 \times 22 \times 300 \times 4.5}{13.5} = 26,500
\]

Total tonnage left in the block: \(51,500\) tons

Approximate percentage of recovery of the mineable area:
\[
\frac{150,000 - 51,500}{150,000} = 71\%
\]

Approximate tonnage to be mined by open-stope mining:
\[
150,000 - 51,500 - (\frac{300 \times 7 \times 10 \times 4.5}{13.5}) = 91,500\text{ tons}
\]

Cost per ton by open-stope mining:

3 miners will drill blast and scrape into the chute one round per shift.
\[
\frac{60 \times 4.5 \times 5}{13.5} = \text{width x height x advance} = 100\text{ tons/shift}
\]

Estimated time of completion of the block - 915 days or 4.7 months.

1. Labor and Supervision:

3 miners at $17.00 per day \(915\) days \(\$6,665.00\)

1/6 shift boss at $600.00 per month \(\times 4.7\) months \(\$4,700.00\)

\(\$51,365.00\)

2. Operating equipment and supplies:

27,450 feet of fuse qt $1.37 per 100 feet \(\$3,760.65\)

27,450 caos at $2.30 per 100 \(631.35\)

-19-
explosives 48,000 lbs at $22.40 per cwt $10,752.00

carbide bits 150 at $15.60 each 2,340.00

100 6 foot length drill rods at $9.10 each 910.00

2-50 foot 1/2" water hose at $28.80 each 57.60

2-50 foot 3/4" air hose at $34.40 each 68.80

2 line oilers at $21.00 each 42.00

$18,562.40

3. Operating equipment to be used:

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Depreciation/mo.</th>
<th>No. used</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coppus fan</td>
<td>$ 5.00</td>
<td>47</td>
<td>$235.00</td>
</tr>
<tr>
<td>5</td>
<td>mine lamps</td>
<td>2.50</td>
<td>&quot;</td>
<td>117.50</td>
</tr>
<tr>
<td>2</td>
<td>Copco drills</td>
<td>18.00</td>
<td>&quot;</td>
<td>846.00</td>
</tr>
<tr>
<td>1</td>
<td>slusher</td>
<td>29.30</td>
<td>&quot;</td>
<td>1,377.10</td>
</tr>
<tr>
<td>1</td>
<td>bucket</td>
<td>5.00</td>
<td>&quot;</td>
<td>235.00</td>
</tr>
<tr>
<td></td>
<td>hand tools</td>
<td>15.00</td>
<td>&quot;</td>
<td>705.00</td>
</tr>
</tbody>
</table>

$3,515.60

4. Miscellaneous, unemployment insurance, F.I.C., etc.,

approximately 15% of 51,365.00 $ 7,704.74

Totals:

Labor and Supervision $51,365.00

Operating equipment and supplies 18,562.40

Operating equipment to be used 3,515.60

Miscellaneous 7,704.75

$81,147.75
Cost per ton of ore extracted by open-stope mining method.

\[
\text{total cost} = \frac{81147.75}{91500} = 0.8868
\]

Development cost per ton of ore mined by an open-stope mining method.

Drifting costs $77,135.00
Raising costs $77,421.19

\[
\text{total costs} = \frac{154556.19}{91500.00} = 1.689
\]

Development costs per ton of ore to be mined by the planer.

Drifting costs $77,135.00
Raising costs \(11,060.17\)

\[
\text{total costs} = \frac{88195.17}{150000.00} = 0.588
\]
Entire block to be extracted by planer mining method.

Average tons to be mined by the planer per operating hour - 26.6

Approximately 6 operating hours per shift, therefore, 160 tons per day.

Estimated time to extract 150,000 tons - 983 days or 47 months.

1. Labor and Supervision:

   1 hoistman at $17.00 per day 938 days $15,946.00
   1 slusher at $17.00 per day 938 days $15,946.00
   1 supervisor and observer at $600.00 per month 47 mo. $28,200.00

   $60,092.00

2. Operating equipment and supplies:

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Depreciation/mo.</th>
<th>Months used</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>hoist</td>
<td>$62.50</td>
<td>47</td>
<td>$2,937.50</td>
</tr>
<tr>
<td>1</td>
<td>slusher</td>
<td>$29.40</td>
<td></td>
<td>1,377.10</td>
</tr>
<tr>
<td>1</td>
<td>bucket</td>
<td>$5.00</td>
<td></td>
<td>235.00</td>
</tr>
<tr>
<td>1</td>
<td>planer</td>
<td>$667.00</td>
<td></td>
<td>16,675.00</td>
</tr>
<tr>
<td></td>
<td>350 feet of air hose 1(\frac{1}{2})&quot; at $60.00 per 100 feet</td>
<td>$420.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20% of $420.00 for fittings</td>
<td>$84.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>mine lamps</td>
<td>$2.50</td>
<td>47</td>
<td>$117.50</td>
</tr>
<tr>
<td></td>
<td>Power approximately $3.00 per day</td>
<td>938 days</td>
<td>$3,760.00</td>
<td></td>
</tr>
</tbody>
</table>

$25,605.10
3. Miscellaneous, unemployment insurance, F. I. C., etc.,

approximately 15% of 60,092.00 $9,013.80

Totals:

Labor and Supervision $60,092.00
Operating equipment and supplies 25,606.10
Miscellaneous 9,013.80

$94,711.90

Cost per ton of ore to the chute or sill.

\[
\frac{\text{total costs}}{\text{total tons mined}} = \frac{94,711.90}{150,000} = \frac{94,711.90}{150,000} = \$0.634
\]
IDEALIZED SECTION AND PLAN
for long wall mining

Haulage level to shaft.

January 1957 -
IDEALIZED SECTION AND PLAN
for long wall mining