

COST OF INITIAL MINING EXCAVATIONS

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by

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Cost of Initial Mining Excavations.

A large part of the early development work on most mining properties consists of surface excavations, such as open cuts, trenches, shallow shafts, and short tunnels. Of this work the greater proportion may be classed as the annual labor performed on unpatented claims. This assessment work entails the expenditure of large sums each year throughout the mining regions of the West. The unit cost of this work, of course, varies greatly under the peculiar conditions applicable to particular localities. There is, however, a much greater difference in the cost of mining work in separated regions as depth is reached.

During the last five years in the Northwest, in inspecting about \$750,000 worth of surface prospect work, I have taken advantage of many opportunities to collect authentic cost data along this line. The figures given in this article are all for hand work. In the specific cases to which references are made, an average efficiency of the labor was obtained. With a higher efficiency, undoubtedly much lower costs could be shown in some cases.

The performance of assessment work is not taken seriously by a great many people, particularly when the owner

does the work himself, not with a view to the real development of the ground, but merely to hold it. In such cases it is only natural to expect that the amount of work will be stinted. Men usually apportion to themselves higher wages than they could obtain elsewhere, and in addition work very short hours. Where owners hire the work done, no matter for what purpose the ground is held, they aim to get full value for the money expended.

There is a sort of tradition among many miners and claim owners that all assessment work is worth \$10 per foot, and that the United States Government will allow that valuation for the work when passing on claims for patent. This is not the case, however, as the law pertaining to the statutory expenditure on a claim is very specific as to the value of the work required, and no mention is made of feet or yardage. When a full \$100 has not been expended as annual labor on an unpatented claim, it is subject to adverse location, no matter how many feet of work have been done. Accordingly, it behooves every owner of unpatented mining property to acquaint himself with the reasonable value of work performed upon his claims, so that he may be in a position to protect himself from a charge of abandonment for failure to do the requisite amount of assessment work.

Quite often among non-mining claim owners, or even among some mining men, there is a misconception of the actual cost of surface mining work. A miner, on completing work on a mining claim, will generally report so many feet of tunnel run, or of shaft sunk, for a certain amount of money expended. To a man who has no way of knowing the cost of surface work, this reported cost may sound reasonable, but not to a man of experience in this line. As an instance: a miner, who had been hired by a claim owner to do the annual labor, reported a 10 ft. shaft sunk for the \$100. The owner, who remembered reading mining companies' reports of shafts which cost from \$40 to \$150 per foot, considered he was receiving his money's worth; while, as a matter of fact, the miner should in this case have sunk four 10 ft. shafts for the \$100.

Throughout the country great numbers of unpatented mining claims which show promise, and in which the owners have faith, are held by business and professional men who, in having the annual assessment work performed, want every dollar to count in the way of developing the ground. Usually men are employed on a daily wage basis to do this work, nearly always unsupervised. It is difficult to get full returns for the money thus paid for unsupervised labor, but a great many claim owners insist on getting fair returns and take steps to insure good results by making it clear to the miners that

they are not going on a picnic, and checking up the work as often as possible.

There is no doubt but that ordinarily greater efficiency can be obtained from men working under direct supervision, as in a city trench, than working without it in some remote place. This does not, however, necessarily mean that the unit of a large operation carried on by fully supervised labor can be conducted more cheaply than can the small job performed by unsupervised workmen. This is attributable to the absence of all overhead and depreciation charges on small jobs, such as large contractors have to carry. Quite often where only a few men are working there is no overhead expense whatever to charge against the cost of the work.

Another thing to keep in mind is the correct number of men to be put on a job to get the best results. In this respect there are other things to consider besides the placing of the men with a view of working to the best advantage. A case has been directed to my attention where two men were sent out to a camp in the hills to do the annual labor on two lode claims. After the completion of the work on the first claim, a third man was sent out to help finish the job. In checking up the results, it was found that more work was done for the \$100 on the first claim than on the second, under identical working conditions. The mystery was finally solved when it occurred to the owner that "slough" is a three-handed game.

Increased cost of work naturally results where higher wages are paid and the working day is shorter, but the resulting increase is seldom as much as the price per hour per man would appear to indicate. Men working on an 8-hour day will generally do a greater amount of work per hour than those working on a 10-hour day. It was noticed in places underground that when an 8-hour, instead of a 10-hour, schedule was put into effect, practically the same amount of work was accomplished in the shorter shift.

Better work may be expected, other conditions being equal, from miners in a \$4 camp than from those in a \$3 one. The mines paying the higher wages naturally have a larger number of men from which to choose their workers. As a rule, high priced men are more efficient than those receiving smaller wages. As an example: on a rush job miners at \$3.25 per 8-hour day were put to work to help finish an excavation on which a Greek section crew were working at \$1.75 per 10-hour day. The cost per cubic yard of the work done by the miners was a little less than that done by the section crew. This is, of course, an exceptional case, and allowance must be made for cost per hour of labor.

Places ^hwhere surface excavations are made are generally in the outskirts of the main districts, or in places remote from centers of population, where it is necessary for the men either to go some distance to work or live at a camp. Generally, the more efficient men are not obtainable to do

this work at the standard scale of wages for the locality. Usually such jobs are relatively short, and have other obvious disadvantages, to offset which it is often customary to pay \$.25 or \$.50 per shift more than the standard scale.

It sometimes occurs, though seldom, that a shaft or tunnel may be started at the surface where the rock is unaltered and may be as difficult to excavate as at depth. Ordinarily, the work is in rock affected by weathering and decomposition. In most mining districts, the sedimentary rocks are shattered and softer at the surface. The igneous rocks also have the same tendency toward disintegration, particularly in the vicinity of veins. Exposed rock is very seldom as hard as that found at depth.

The simplest forms of development work are open cuts and trenches. Later, when the location of the lead is determined, shafts may be sunk, or, if the contour of the ground is favorable, tunnels run.

In computing costs, open cuts and trenches are calculated on a cubic yardage basis, and shafts and tunnels by the linear foot, due allowance being made for the size of the cross sections. A good method of arriving at the cost of prospect shafts is to figure the first 7 feet as an open cut on a yardage basis, and from there down as a shaft at so much per foot in depth. Material can be readily thrown with a shovel from a depth of 7 feet. To do so from a

greater depth increases the cost per cubic yard, and, where a windlass is to be installed in any event, it is not economy. It is common practice in city trenches, and to some extent in shafts where no greater depth is desired, to throw material from a distance of 8 or 9 feet below the surface. Shafts are often sunk to a depth of 15 feet or more without installing a windlass, the material excavated being thrown to the surface by means of benches. The broken rock is thrown from the bottom to a bench and from there to the surface.

The cost per cubic yard of open cuts varies from \$.50 to several dollars; prospect tunnels from \$2.50 to \$30 per foot; and prospect shafts from \$4 to \$40 per foot, depending upon the varying conditions. The cross sections of such tunnels and shafts are generally 4 x 6 feet.

Material removed in making excavations is classified as follows:

Earth or overburden, including clay, loam, sand and gravel;

Loose rock, including shale, decomposed rock, boulders and detached masses less than 3 cubic feet, and all other masses of rock that can be loosened with a pick, although blasting may be resorted to in order to expedite the work;

Solid rock, including rock found in place in ledges and masses, or boulders measuring more than 3 cubic feet, which can only be moved by blasting.

At Butte, with miners' wages \$3.50 per 8-hour shift, the cost of open cut work averages about \$1.00 per cubic yard. The formation is a quartz monzonite, locally

known as the Butte granite. This rock, with the exception of unaltered boulders and an occasional ledge of solid granite which outcrops, decomposes at the surface and to quite a depth in the proximity of veins. The boulders are mainly at the surface, but are frequently found below and in veins at depth. There is almost an entire absence of any angular slide overburden. At points where the granite is well disintegrated, the cost of open cut work will be less than \$1.00 per cubic yard. On the other hand, where boulders are encountered and in ledges of solid granite, the cost will be considerably higher. Excavations in this district are nearly always started in the decomposed granite. There is not much object in starting them in hard rock, as no vein outcrops are found in the unaltered portions. The altered granite near the surface is mostly picking ground, and little blasting is required in open work.

The cost of short tunnels from the surface at Butte runs from \$3.00 to \$8.00 per foot, except some work on the main range in hard aplite which costs over \$10.00 per foot. In the majority of cases involving decomposed granite, the cost is between \$4.00 and \$5.00 per foot. This includes cutting the timber, if standing on the claim or nearby, and placing it in the tunnel, but not its purchase price or the expense of bringing it from a distance. Generally, where the rock is soft enough to require timbering, the greater ease with which it is broken will compensate

for the extra labor of cutting timber and putting in sets. Where the tunnels run into spiling ground and into hard boulders, the cost will, of course, be increased. These figures do not refer to tunnels of large cross section in the solid granite in the deep mines.

The cost per foot of sinking prospect shafts in the Butte granite depends on the amount of decomposition of the rock, and on the depth of the shaft. Prospect shafts are generally about 4 ft. wide and 6 ft. long, as this makes a convenient sized excavation in which one man may work. The average cost of a 4 x 6 shaft 15 ft. deep is about \$5.00 per foot below a depth of 7 feet, the upper 7 feet being figured on a yardage basis. The cost increases with depth. A 4 x 6 shaft 10 feet deep is generally considered by the United States Mineral Surveyors and others at Butte as costing \$25. This is generally a fair valuation, but in some cases it is a little high.

Patent work amounting to \$25,000 done under the supervision of two men on about fifty scattered lode claims, ranging from four to six miles from Butte, showed a cost of \$.80 to \$1.25 per cubic yard for open cut work, and an average of \$5.00 per foot for tunnels. The work done on a single claim of this number for an expenditure of \$500 aggregated 113 cubic yards of open cuts and a partly timbered tunnel 3 x 6 x 84 ft. long. The cost of the tunnel, by allowing

\$1.00 per cubic yard for the open work, was \$4.60 per linear foot. The work on all of the claims consisted of open cuts and tunnels, with a few shafts. The deepest shaft was 55 ft. deep, and the others were comparatively shallow. The cost of the deepest shaft to a depth of 47 ft. was \$370, or nearly \$8.00 per foot, and to the depth of 55 ft. \$470, making the last 8 feet cost \$12.50 per foot. This shaft was sunk on a vein on a 45° incline, and was cribbed with an inside measurement of 3 x 5 feet. The broken rock was hoisted by a hand windlass in a bucket sliding up on guides. In this case, the construction of the windlass and frame and other extra work made up for the smaller cost of the first 7 feet. The formation was more or less decomposed Butte granite, and required blasting. From the last part of the shaft some water had to be bailed. It is considered that 55 feet is just about the limit for economical sinking with a hand windlass.

Another shaft 4 x 6, 15 ft. deep, cost \$48. This amounted to \$1.00 per cubic yard for the first 7 feet, and a little over \$5.00 per foot for the remainder.

Tables "A" to "F" inclusive are cost records of development work performed on individual mining claims in the Butte District three to six miles from Butte. Wages \$3.50 for eight hours.

Excavations:	Dimensions	Contents	Cost	Unit Cost	Material
Shaft	:4x6x47 deep) timbered)	:47 lin. ft.	: \$400.00	: \$8.51 per ft.	: decomposed granite
Shaft	:3x4x6 deep	: 2.7 cu. yd.	: 2.65	: .99 per cu. yd.	: "
Shaft	:4x5x6 deep	: 4.4 cu. yd.	: 3.50	: .79 "	: disintegrated granite
Shaft	:4x5x6 deep	: 4.4 cu. yd.	: 3.50	: .79 "	: "
Shaft	:5x5x4 deep	: 3.7 cu. yd.	: 3.50	: .95 "	: decomposed granite
Cut	:4x18x6 face	: 8 cu. yd.)	:	: .90 "	: "
Tunnel	:3x6x8 long	: 8 lin. ft.)	: 38.50	: 3.91 " lin. ft.	: "
Cut	:3x5x103 long	:34.3 cu. yd.	: 28.00	: .82 " cu. yd.	: disintegrated granite
Cut	:3x3x122 long	:40.7 cu. yd.	: 35.00	: .86 "	: "
Cut	:3x2½x15 long	: 4.1 cu. yd.	: 3.50	: .85 "	: "
Cut	:3x2x12 long	: 2.7 cu. yd.	: 2.65	: .98 "	: "
Cut	:2x1½x24 long	: 2.7 cu. yd.	: 1.75	: .65 "	: "
Cut	:3½x2½x45 long	:14.6 cu. yd.	: 12.25	: .84 "	: "
Cut	:2½x2½x15 long	: 3.5 cu. yd.	: 3.50	: 1.00 "	: "

Average cost of open work \$8.51 per cu. yd.

Average cost of sinking \$3.91 per lin. ft.

Average cost of tunneling \$3.91 per lin. ft.

Excavations:	Dimensions	Contents	Cost	Unit Cost	Material
Cut Tunnel	:5x22x8 face	:16.3 cu. yd.)	: \$56.00	: \$1.50 per cu. yd.	: decomposed granite
	:4x6x11 long	:11 lin. ft.)	:	: 2.88 " lin. ft.	: "
Shaft	:5x6x6 deep	: 6.7 cu. yd.	: 7.00	: 1.04 " cu. yd.	: " " "
Shaft	:4x5x6 deep	: 4.4 cu. yd.	: 10.50	: 2.38 " "	: shattered aplite
Tunnel	:4x6x19 long	:19 lin. ft.	: 150.00	: 6.08 " lin. ft.	: blocky decomposed granite
Cut	:4x31x10 face	:23.0 cu. yd.	:	: 1.50 " cu. yd.	: decomposed granite

Average cost of open work \$1.52 per cu. yd.

Average cost of tunneling \$4.90 per lin. ft.

"C"

Excavations:	Dimensions	Contents	Cost	Unit Cost	Material
Shaft	4x6x5 deep	4.5 cu. yd.)	\$ 15.75	\$.93 per cu.yd.	decomposed granite
Cut	4x5½x24 long	12.4 cu. yd.)	2.93		"
Cut	3x3x12 long	4.0 cu. yd.	3.50	.88	"
Cut	4x6x21 long	18.7 cu. yd.		1.50	"
Tunnel	3x6x73 long	73.0 lin.ft.	420.00	5.37	" lin.ft.
Cut	3x3x160 long	53.2 cu. yd.	50.00	.94	" cu.yd.
Cut	4x4x15 long	8.9 cu. yd.	8.75	.98	"
Shaft	3x3x4 deep	1.3 cu. yd.)		.95	"
Shaft	4x4x2½ deep	1.5 cu. yd.)	2.65	.95	"

Average cost of open work \$1.04 per cu. yd.

Average cost of tunneling \$5.37 per lin. ft.

"D"

Excavations:	Dimensions	Contents	Cost	Unit Cost	Material
Shaft	:4x8x7 deep	: 8.3 cu. yd.	: \$ 14.00	: \$1.69 per cu.yd.	: compact decomposed granite
Cut	:4x2x27 long	: 8.0 cu. yd.	: 7.00	: "	: decomposed granite
Cut	:4x5x36 long	:26.7 cu. yd.	: 24.50	: "	: "
Cut	:3x3x27 long	: 9.0 cu. yd.	: 7.00	: "	: "
Cut	:3x4x27 long	:12.0 cu. yd.	: 10.50	: "	: "
Shaft	:3x5x4 long	: 2.2 cu. yd.	: 2.00	: "	: "
Shaft	:4x5x4 deep	: 3.0 cu. yd.	: 2.65	: "	: "
Shaft	:3x4x5 deep	: 2.2 cu. yd.	: 2.00	: "	: "
Cut	:4x13x7 face	: 6.7 cu. yd.	: 6.15	: "	: "
Tunnel	:3x6x47 long	:47.0 lin.ft.	: 300.00	: 6.38 " lin.ft.	: compact decomposed granite
Cut	:2x2½x15 long	: 2.6 cu. yd.	: 2.65	: 1.02 " cu.yd.	: decomposed granite

Average cost of open work \$.97 per cu. yd.

Average cost of tunneling \$6.38 per lin. ft.

"E"

Excavations:	Dimensions	Contents	Cost	Unit Cost	Material
Cut	5x20x6 deep	22.4 cu.yd.	\$ 21.00	\$.94 per cu.yd.	decomposed granite
Cut	6x10x7 deep	15.5 cu.yd.	17.50	" "	"
Cut	4x42x8 face	25.0 cu.yd.	24.50	" "	"
Tunnel	4x6x195 long	195 lin. ft.	900.00	4.62 " lin.ft.	"

Average cost of open work \$1.00 per cu. yd.

Average cost of tunneling \$4.62 per lin. ft.

"P"

Excavations:	Dimensions	Contents	Cost	Unit Cost	Material
Shaft	4x9x10 deep	9.3 cu. yd. 3 ft. sinking	\$ 30.00	\$1.50 per cu. yd. 5.33 " lin. ft.	decomposed granite
Cut	5x28x5 deep	26.0 cu. yd.	25.00	.96 " cu. yd.	"
Cut	4x4x22 long	13.0 cu. yd.	21.00	1.62 " "	tough, compact decomposed granite
Cut	4x3x22 long	9.8 cu. yd.	17.50	1.78 " "	tough, compact decomposed granite
Cut	4x6x12 long	10.6 cu. yd.	21.00	1.98 " "	tough, compact decomposed granite

Average cost of open work \$1.43 per cu. yd.

Average cost of sinking \$5.33 per lin. ft.

The cost to the city of Butte of excavating the material in sewer trenches within the granite area amounted to \$2.16 per cubic yard. The trenches were 2 feet wide and averaged 9 feet deep. All the work was done by contractors. Wages for ditch diggers are \$4.00 per 8 hours, this being the minimum price for all laborers on city work, and is \$.50 per day more than is normally paid to miners. This rate of wage has been fixed by ordinance of the city government. City contractors in Butte have to contend with numerous labor union regulations. The higher cost per yard of this work than for open cut mining is due to the labor situation, the greater depth and small width of the trenches, and the larger proportion of solid granite, consisting of boulders and ledges included in the softer material which has to be moved.

A 300 ft. tunnel run from the surface in a hard, compact granite cliff at the head of Rattlesnake Creek in Beaverhead County, Montana, cost \$28.00 per foot.

Several hundred feet of prospect tunnels on the Porphyry Dyke in the Remini District, Montana, were run by contract for \$3.00 per foot.

Prospect tunnels in the soft porphyry in the Lowlands District, Montana, cost from \$2.00 to \$5.00 per foot.

Tunnels in the soft schist in the Crevasse Mining District, Montana, cost from \$4.00 to \$5.00 per foot.

In the Coeur d'Alene Mining District there are very few outcrops, and the surface on the mountainsides is generally covered with soil and angular wash to a depth of 2 to 8 or 10 feet. Under the overburden, the formation in place nearly always is broken and shattered to an appreciable depth, but very seldom over 15 feet or 20 feet. The formation is a series of sedimentary rocks which are, on the whole, easily eroded and weathered. There are a few hard strata, such as the copper beds in the Revette quartzite, which resist weathering, and are as hard at the surface as at depth, but these comprise only a very small part of the whole series. Miners' wages are normally \$3.50 for 8 hours. The cost of surface cuts here is found to be a little higher than at Butte, averaging about \$1.20 per cubic yard for the material removed. Individual cuts cost from \$.75 per cubic yard when in wash, to \$2.00 per cubic yard when in the harder rock. The average cost of a series of cuts up to 7 feet in depth on flat surfaces and with 12 ft. faces on side hills, was \$1.20 per cubic yard. In classifying the material, most of the rock in place in open cut work would come under the head of loose rock. The average rock in the Coeur d'Alene is much softer than the solid granite at Butte, but harder than the altered granite.

The cost of prospect tunnels in the Coeur d'Alenes ranges from \$3.50 to \$10.00 per foot, according to the hardness of the rock, with an average of about \$6.00. The contract price of a tunnel in the shale above Pottsville, Idaho, from 400 to 500 feet from the portal, was \$4.50 per foot. The total cost to the contractor, however, was \$3.50 per foot. Surface prospect tunnels run by one of the mining companies in hard quartzite at Burke, Idaho, cost \$10.00 per foot.

Tables "G" to "M" inclusive are cost records of development work performed on mining claims in the Coeur d'Alene District. Wages \$3.50 for eight hours.

"G"

Excavations	Dimensions	Contents	Cost	Unit	Cost	Material
Cut	5x21x10 face	19.4 cu.yd.	\$ 28.00	\$ 1.45	per cu.yd.	$\frac{1}{2}$ slide, $\frac{1}{2}$ broken quartzite in place
Cut	5x18x10 face	16.7 cu.yd.	24.50	1.48	" "	$\frac{1}{2}$ slide, $\frac{1}{2}$ broken quartzite in place
Cut	4 $\frac{1}{2}$ x25x10 face	20.8 cu.yd.	31.50	1.51	" "	$\frac{1}{2}$ slide, $\frac{1}{2}$ broken quartzite in place
Tunnel	4 $\frac{1}{2}$ x6x35 long	35 lin. ft.	300.00	8.57	lin.ft.	along fissure in quartzite
Tunnel	5x7x174 long	174 lin. ft.	1700.00	9.77	" "	cross cut in quartzite

Average cost of open work \$1.50 per cu. yd.

Average cost of tunneling \$9.57 per lin. ft.

This work was performed in developing a group of claims in the Burke quartzite near Burke, Idaho.

Excavations	Dimensions	Contents	Cost	Unit Cost	Material
Cut	5x8x10 face	16.7 cu.yd.	\$ 21.00	1.26 per cu.yd.	$\frac{2}{4}$ overburden, $\frac{1}{4}$ broken quartzite in place
Tunnel	4 $\frac{1}{2}$ x6x195 long	195 lin. ft.	2000.00	10.25 " lin.ft.	crosscut in quartzite
Tunnel	5x6x110 long	110 lin. ft.	1300.00	11.82 " "	main working tunnel in hard quartzite
Cut	5x14x10 face	13 cu. yd.	21.00	1.62 " cu. yd.	$\frac{1}{2}$ overburden, $\frac{1}{2}$ broken quartzite
Cut	5x15x10 face	13.8 cu. yd.	21.00	1.52 " "	do
Cut	5x18x10 face	16.7 cu. yd.	24.50	1.47 " "	do
Cut	5x16x10 face	14.8 cu.yd.	21.00	1.42 " "	do
Cut	5x20x10 face	18.5 cu. yd.	28.00	1.51 " "	do
Cut	5x20x10 face	18.5 cu. yd.	24.50	1.32 " "	$\frac{2}{4}$ overburden, $\frac{1}{4}$ broken quartzite

Average cost of open work \$1.44 per cu. yd.

Average cost of tunneling \$10.82 per lin. ft.

This work was performed in developing a group of claims near Burke, Idaho, in the Burke quartzite. The 110 ft. tunnel is part of a main working tunnel about 2000 ft. under ground in unaltered quartzite.

Excavations	Dimensions	Contents	Cost	Unit Cost	Material
Tunnel	4½x6½x48 long	48 lin.ft.	\$ 300.00	6.25 per lin.ft.	on narrow vein in quartzite
Cut	5x15x10 face	13.9 cu.yd.	14.00	1.01 per cu.yd.	slide rock and soil
Cut	5x15x10 face	13.9 cu.yd.	12.25	.88	" "
Cut	5x20x10 face	18.5 cu.yd.	19.25	1.04	" "
Cut	5x15x10 face	13.9 cu.yd.	14.00	1.01	" "
Tunnel	4½x6x159½ long	159½ lin.ft.	1200.00	7.53	" lin.ft.: along 4' vein in quartzite
Cut	5x12x12 face	13.3 cu. yd.	14.00	1.05	" cu.yd.: slide rock and soil
Cut	5x15x12 face	16.7 cu.yd.	17.50	1.05	" "
Cut	5x14x10 face	13.0 cu.yd.	12.25	.94	" "

Average cost for open work \$1.00 per cu. yd.

Average cost for tunneling \$7.23 per lin. ft.

This work was performed near Mullan, Idaho, in the St. Regis formation.

"J"

Excavations	Dimensions	Contents	Cost	Unit Cost	Material
Tunnel	4x6x55 long	55 lin. ft.	\$300.00	\$5.45 per lin. ft.	in overburden, timbered
Tunnel	4x6x45 long	45 lin. ft.	200.00	4.44 "	" "
Tunnel	4½x6x12 long	12 lin. ft.	60.00	5.00 "	half "
Tunnel	5x6x10 face	10 lin. ft.	31.50	3.15 "	not "

Average cost for tunneling \$4.85 per lin. ft.

This work was performed in a glacial deposit near Mullan, Idaho.

"K"

Excavations	Dimensions	Contents	Cost	Unit Cost	Material
Tunnel	4½x6x70 long	70 lin. ft.	\$ 500.00	\$7.14 per lin. ft.	in shaly quartzite
Tunnel	4x6x300 long	300 lin. ft.	2000.00	" "	on 5' fissure in shaly quartzite
Tunnel	4x6x66 long	66 lin. ft.	400.00	" "	in shaly quartzite
Tunnel	4½x6x60 long	60 lin. ft.	350.00	" "	in shaly quartzite

Average cost of tunneling \$6.55 per lin. ft.

This work was performed in the Wallace formation near Mullan, Idaho.

"L"

Excavations	Dimensions	Contents	Cost	Unit Cost	Material
Cut	4x18x8 face	10.7 cu. yd.	\$19.25	\$1.80 per cu.yd.	quartzite
Cut	4x12x6 face	5.3 cu. yd.	10.50	2.03 "	"
Cut	4x20x8 face	11.8 cu. yd.	17.50	1.48 "	shaly quartzite
Cut	5x14x6 face	7.8 cu. yd.	12.25	1.58 "	"
Cut	5x14x6 face	7.8 cu. yd.	14.00	1.80 "	"

Average cost of open work \$1.69 per cu. yd.

This work was performed in the Burke and St. Regis formations near Larson, Idaho.

"M"

Shaft 4 x 10 x 10 deep, $\frac{1}{2}$ in overburden and $\frac{1}{2}$ in shaly quartzite. Cost \$27.00. Contents 14.8 cu. yds. Unit cost \$1.82 per cu. yd. for total of shaft, or \$2.70 per lin. ft. By figuring first 7 feet containing 10.4 cu. yds. at \$1.35 per cu. yd., the last 3 feet would cost \$4.32 per lin. ft.

Shaft 6 x 10 x 10 deep, $\frac{1}{4}$ in overburden and $\frac{3}{4}$ in quartzite. Cost \$50. Contents 22.2 cu. yds. Unit cost \$5.00 per lin. ft., or \$2.25 per cu. yd. By figuring first 7 feet containing 15.6 cu. yds. at \$2.00 per cu. yd., the last 3 ft. would cost \$6.27 per lin. ft.

Shaft 6 x 10 x 10 deep, $\frac{1}{2}$ in overburden and $\frac{1}{2}$ in shaly quartzite. Cost \$40. Contents 22.2 cu. yds. Unit cost \$4.00 per lin. ft., or \$1.81 per cu. yd. By figuring the first 7 feet containing 15.6 cu. yds. at \$1.35 per cu. yd., the last 3 feet would cost \$6.31 per lin. ft.

All of the work above Larson, Idaho, in the Revette formation.

Annual assessment work on five lime placer claims twelve miles from the railroad on Pend Oreille River, in Washington, showed an average cost of \$3.23 per cubic yard of rock removed. Wages \$3.50 for 9 hours. The formation was tough, compact limestone and dolomite, with an entire absence of all surface weathering and overburden. The cuts were made in the bluffs above the river.

The following table "N" is a record of this work.

"N"

<u>Claim:</u>	<u>Cost</u>	<u>:</u>	<u>cu. yds.</u>	<u>:</u>	<u>cost per cu. yd.</u>
1	: \$100	:	3.5	:	\$2.76
2	: 100	:	3.0	:	3.33
3	: 100	:	2.6	:	3.85
4	: 100	:	2.6	:	3.85
5	: 100	:	3.8	:	2.63

Average cost \$3.23 per cu. yd.

The work was performed in the middle of winter in severe weather.

The cost of supplies was from \$4.15 to \$10.00 of every \$100.00 expended. All supplies were brought in by pack train, and cost of transportation was charged against the job.

The men were boarded in a camp nearby at a cost of \$.96 to \$1.04 per day per man and \$1.00 per day was deducted from the workmen's wages to cover this expense.

Wages \$3.50 for nine hours.

Development work in open cuts on lime placer claims at Metaline Falls, Washington, in solid limestone, cost from \$2.50 to \$4.10 per cubic yard. Wages \$3.50 for 9 hours.

Table "0" is a record of this work.

Excavations	Dimensions	Contents	Cost	Unit Cost	Material
Cut	:15x10x8 face	: 22.2 cu. yd.	: \$ 60.00	: \$2.70 per cu.yd.	: solid blue limestone
Cut	:54x12x10 face	:120.0 cu.yd.	: 400.00	" 3.53	" "
Cut	:12x8x10 face	: 17.8 cu.yd.	: 50.00	" 2.81	" "
Cut	:80x17x7 face	:176.0 cu.yd.	: 500.00	" 2.83	:shaly limestone
Cut	:80x15x1 deep	: 44.5 cu.yd.	: 75.00	" 1.69	: stripping
Cut	:15x15x6 face	: 25.0 cu.yd.	: 100.00	" 4.00	:solid blue limestone
Cut	:18x15x10 face	: 50.0 cu.yd.	: 200.00	" 4.00	" "
Cut	:40x15x6 face	: 66.7 cu.yd.	: 200.00	" 3.00	:shaly limestone
Cut	:80x18x6 face	:160.00 cu.yd.	: 150.00	" .94	:stripping
Cut	:40x15x3 face	: 33.3 cu. yd.	: 100.00	" 3.00	:shaly limestone
Cut	:40x30x3 face	: 66.7 cu.yd.	: 75.00	" 1.12	:stripping
Cut	:20x15x5 face	: 27.7 cu.yd.	: 70.00	" 2.50	: shaly limestone

Average cost of open work in solid rock \$3.12 per cu. yd.

Average cost of stripping \$1.11 per cu. yd.

The cost per cubic yard of open cuts on a vein in disintegrated andesite on the north half of the Colville Indian Reservation, Washington, was \$.94 per cubic yard. The cuts averaged 34 feet long, with 15 feet faces. Wages \$3.50 for 9 hours.

The contract price for excavating solid rock in trenches 3 x 9 feet deep in the city of Spokane, Washington, was \$4.75 per cubic yard. This rock is a basalt of extreme toughness, and requires an excessive amount of drilling and blasting. The contract price for the same work in open cuts in street work was from \$.90 to \$1.25 per cubic yard. The cost to the city for removing gravel in the same size trenches was \$.90 to \$1.00 per cubic yard. Wages are \$3.00 for 8 hours, for city work. The contractors figure 20% of the cost consists of overhead charges, interest and depreciation, and 6% tax for workmen's compensation.

Open cuts made at Bingham, Utah, in weathered limestone and quartzite and slide rock, under my direction, cost \$.80 per cubic yard. Prospect tunnels in the same formation cost \$4.00 to \$6.00 per foot. Miners' wages were \$3.25 for 8 hours. Table "P" is a record of some of this work.

"P"

Excava- tions	Dimensions	Contents	Cost	Unit Cost	Material
Tunnel	5½x6x18 long	18.0 lin.ft.	\$100.00	\$5.55 per lin.ft.	limey quartzite
Tunnel	4x6x24 long	24.0 lin.ft.	100.00	4.17	shattered quartzite
Tunnel	4x6x25 long	25.0 lin.ft.	100.00	4.00	"
Tunnel	4x6x66 long	66.0 lin.ft.	400.00	6.06	"
Cut	10x12x8 face	17.8 cu. yd.	13.80	.77	overburden, ½ weathered limestone
Cut	4x14x10 face	10.4 cu. yd.	9.75	.94	¼ overburden, ¾ weathered limestone
Cut	5x4x10 long	4.4 cu. yd.	3.25	.74	all overburden
Cut	4x6x7 deep	6.2 cu. yd.	4.90	.78	½ overburden, ½ weathered limestone
Cut	4x12x8 face	7.1 cu. yd.	5.70	.81	½ overburden, ½ weathered limestone

Average cost of open work \$\$.81 per cu. yd.

Average cost of tunneling \$5.26 per lin. ft.

Hand placer work is cheaper, on the whole, than the same kind of work on lode claims, which is to be expected from the nature of the material which is handled in each case. The formation of placers consists of stream gravel, sand, or clay, with an occasional boulder, and in some cases cemented strata. Hand placer excavating is straight pick and shovel work, except where boulders are encountered. In hand sinking on many placer properties, the amount of water which has to be bailed or pumped out is the greatest factor in determining the cost, and often the quantity of water prevents sinking entirely. In many places cemented strata are entirely absent, and what boulders are found are near bedrock and need not be moved in prospect work.

By considering how much gravel a man can handle per shift, and his daily wage, it would be possible theoretically to arrive at the cost of most placer excavations. Byrne, on page 202 of his Inspector's Hand Book, gives the average amount of material a man can loosen per hour with a pick as:

Clay or cemented gravel	. 1 yard
Loam or loose gravel	2 to 3 yards
Sand	4 to 6 yards.

On the same page he gives the average quantity a man can shovel per hour with a limit to the cast of 6 feet vertically and 12 feet horizontally, as:

Rock	1 yard
Clay or heavy soils	1.7 yards
Loose earth or sand	2 yards.

By taking Byrne's figures of $2\frac{1}{2}$ yards per hour for loosening gravel, and of 1.7 yards per hour for shoveling, a man, in an 8-hour shift, could excavate a trifle over 8 cubic yards of material. By allowing, for miners, \$3.50 for 8 hours, the cost per yard would be \$.44. This agrees fairly well with other authorities, such as Gillette and Trautwine.

On placers, the cost of open work or trenches up to 7 feet deep, with little or no water, varies from \$.40 to \$1.00 per cubic yard, depending upon the nature of the material and the price of labor. Timbered prospect tunnels in gravel cost generally from \$4.00 to \$6.00 per linear foot. The cost of a 10 foot shaft, with little or no water, is generally taken as being \$10. Frozen gravel is not taken into consideration.

In one of the placer camps in central Idaho a shift's work of 10 hours per man consisted of shoveling a block of ground 4 feet deep, 6 feet wide and 12 feet long into sluice boxes. This is equal to 10.7 cu. yds. of gravel, or 1.07 cu. yds. per hour per man. The boxes were set on top of the ground and the gravel thrown up into them.

Table "Q" shows some cost records obtained on a placer in Western Montana.

"Q"

Excavations	Dimensions	Contents	Cost	Unit Cost	Material
Cut	3x4x48 long	:21.3 cu. yd.	: \$ 7.00	: .53 per cu. yd.	: 2' muck, 1' gravel
Cut	5x4x17 long	:12.6 cu. yd.	: 6.00	" "	: 1½' muck, 2½' gravel
Shaft	4x7x4 deep	: 4.1 cu. yd.	: 2.00	" "	: 1½' muck, 2½' gravel
Shaft	4x7x7 deep	: 7.2 cu. yd.	: 6.00	" "	: all gravel and boulders
Shaft	5x10x6 deep	:11.1 cu. yd.	: 7.00	" "	: 3' muck, 3' gravel
Cut	4x25x5½ deep	:20.3 cu. yd.	: 13.00	" "	: 2' muck, 3½' gravel
Cut	36x4x3 deep	:16.0 cu. yd.	: 6.00	" "	: 1½' muck, 1½' gravel
Cut	4x49x6 face	:21.7 cu. yd.	: 11.00	" "	: glacial drift and silt
Cut	50x4x5 deep	:37.0 cu. yd.	: 21.00	" "	: 1½' muck, 2½' clayey gravel
Trench	42x4x4 deep	:25.0 cu. yd.	: 11.00	" "	: 2' muck, 2' gravel
Trench	75x3x3 deep	:25.0 cu. yd.	: 9.00	" "	: 1½' muck, 1½' gravel
Tunnel	4½x6½x41 long	:41 lin. ft.	: 200.00	: 4.88 " lin. ft.	: glacial drift

Average cost of open work \$.49 per cu. yd.

Average cost of tunneling \$4.88 per lin. ft.

Wages \$4.00 for 8 hours.

In sinking a shaft to test the gravel during the examination of a gold placer claim in central Montana, I carefully timed the work.

The cross section of the shaft was 4 x 6 $\frac{3}{4}$ feet, so that with each foot in depth one cubic yard of material was removed.

I personally did the excavating, with the assistance of one man, under conditions as near as possible to those existing in actual mining operations with unsupervised labor.

Table "R" is a record of the time taken for each foot of excavation.

"R"

Depth:	: Time	: Number of men:	: Equivalent time one man:	: Material
0-1	:12 min.	: 2	: 24 minutes	: Soil and clay.
1-2	:17 "	: 2	: 34 "	: " " "
2-3	:36 "	: 2	: 72 "	: Hard picking gravel.
3-4	:42 "	: 2	: 84 "	: " " "
4-5	:(40 "	: 2)	:	: Hard picking gravel and boulders
	:(40 "	: 1)	:120 "	: Water bailed from 4 $\frac{1}{2}$ ' to 5'.

Below a depth of 2 feet, except when lifting out boulders, only one man worked at a time, each one taking turns with the pick and shovel, while the time of both is included in calculating the costs.

While my assistant worked alone in the shaft, I panned samples of gravel.

Bedrock was reached at a depth of 5 feet. From a depth of 3 to 5 feet boulders were removed up to 200 pounds in weight. Time equal to 30 minutes by one man was consumed in hoisting boulders and bailing water between 4 and 5 feet from the surface.

"T"

Cost of excavating test shaft.			Cost of excavating shaft, Hard picking from surface, From 0-2 ft. calculated.		
Depth:	cu.yd.	Average cost per cu.yd. of hole to depth:	cu.yd.	Average cost per cu.yd. of hole to depth:	
0-1 ft.	\$.20	\$.20	\$.40	\$.40	
1-2 "	.28	.24	.50	.45	
2-3 "	.60	.35	.60	.50	
3-4 "	.70	.45	.70	.55	
4-5 "	1.00	.55	1.00	.65	
5-6 "	Calculated 1.10	.65	Calculated 1.10	.70	
6-7 "	1.20	.75	1.20	.80	

Table "T" is a computation of the cost of each yard and of the average cost of the shaft at each foot in depth. Wages were taken at \$4.00 for 8 hours, or \$.50 per hour.

The figures for the depths of 6 and 7 feet are taken from Curve "S". In the second part of Table "T" the figures are for hard picking gravel from the surface. The costs for a depth from 0-1 and from 1-2 feet are calculated

100

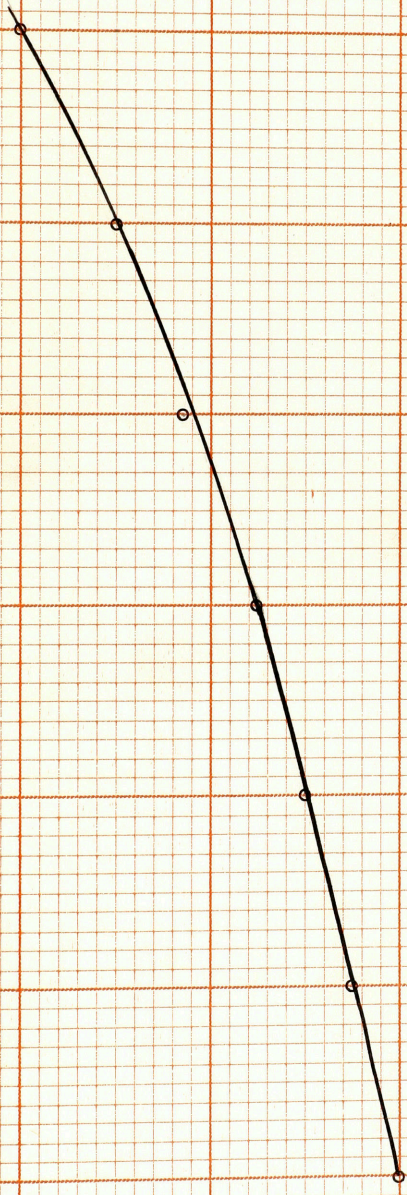
80

60

40

20

0



Curve showing the increase in the cost of p/dcer excavations as the depth is increased.

Material - or hard picking gravel containing boulders and some water.

9
8
7
6
5
4
3
2
1

Depth in Feet

from the costs at depths 2-3 and 3-4.

Curve "S" is platted from information in Table "T". In extending the curve from 4, allowance was made for the extra cost in removing the material at the depth of 5 feet.

Trenches in city streets, particularly in a mountainous country, are quite often in material similar to that found on placers. Costs are generally kept fairly close on this work, and can be used as a basis of comparison for placer work in similar material.

At Missoula, Montana, it costs the Missoula Light & Water Company an average of \$.36 per cubic yard to do the excavating for city water trenches 2 x 6 feet deep. The work is done by day labor, with wages at \$3.00 for 8 hours. The material moved is almost entirely wash gravel, with an occasional hardpan.

In the winter it costs this company an average of \$.81 per cubic yard to remove frozen gravel in trenching to the water mains. The excavations for this purpose ^{are} 2 x 5½ x 20 feet long. It costs about \$1.25 per cubic yard to make excavations 2 x 5½ x 4 feet long to the water mains in isolated parts of the town. These figures do not take into account overhead charges, or include the cost of the wood used in thawing the gravel. By taking into account all expenses that could be charged against the work, the total cost would probably be 20% higher.

The Great Falls Water Company, at Great Falls, Montana, in excavating for city water pipes, moved 89% earth, 5% solid rock and 6% loose rock at an average cost of \$.34 per cubic yard. Wages were \$2.25 for 10 hours.

S. Lefevre, in his article in the February 1915 bulletin of the American Institute of Mining Engineers, gives the cost of surface excavations at Mineville, N. Y., in hardpan and boulders, as \$.80 to \$1.00 per cubic yard. Wages for this kind of work are about \$2.00 for 10 hours.

Well diggers sink 5 x 5 feet wells up to 30 feet in depth on the Missoula Flat, at Missoula, Montana, on contract, at \$1.50 per foot including placing, but not cost, of timber. Below 30 feet the cost increases. The Flat is an old river bottom, and consists mostly of river gravel.

With labor at \$3.00 for 8 hours, it costs about \$.45 per cubic yard to remove overburden with a pick and shovel and wheelbarrow, with a limit of 100 feet to the haul, in excavating for the foundations of concentrators and other buildings on side hills. Removing rock by hand under the same conditions will cost about \$1.25 to \$2.00 per cubic yard. Every 100 feet extra in the haul will increase the cost a few cents per cubic yard. There are so many conditions to be considered in making excavations of this kind that these costs are only approximate.