ments, attends to shipping the ore and to ordering supplies, and often assists in selling ore. One man sometimes represents more than one company in this capacity. A majority of the agents reside in Marquette. The *superintendent*, who by custom has the title of captain, always resides at the mine, directs the work, and is in the main responsible for it. On him as much or more than on any other officer of the company does the success of its operations depend.

The offices of agent and superintendent are sometimes united in the same man. Large mines have a *chief clerk*, who is practically assistant superintendent. Next in order of rank are the foremen, master mechanics, and time-keepers. For names and addresses of agents, superintendents and managing officers, see Statistical Table, Plate XII. of Atlas.

The *organization* of the force of two large mines in the summer of 1870 is shown below. The first mine (I.) shipped the greatest amount of ore, and the second (II.) did most of its dead work in the winter, the aggregate shipments for the two, for that year, being 300,000 tons.

	I.		II.	
Contractors engaged in stripping, sinking, etc..	77		7	
Company account, men, laborers and mechanics on miscellaneous work....................	65		32	
Total employed in *dead work*...........		142		39
Contractors breaking ore....................	117		114	
Company account, men breaking ore..........			25	
Total at *mining* proper..................		117		139
Carpenters and wagon-makers...............	6		6	
Blacksmiths and helpers....................	17		10	
Total mechanics employed in *repairing*....		23		16
Drivers and stable-men.....................	20		12	
Engineers and firemen......................	11		8	
Loading ore from stock-pile.................	18			
Total *handling* ore......................		49		20
Superintendent and clerks..................	3		3	
Foreman, blaster and watchman.............	6		7	
Total *staff* at mine......................		9		10
Total force employed......................		340		224

This force was employed during the period of shipments, hence of greatest activity; after the close of navigation, in November, it would probably be reduced 25 per cent. Less than one-half of the men employed have families, many single men going " outside " in the fall and returning in the spring.

One large mine, the best managed in the region, expended in 1872, 51,000 days' work all told, of which 48 per cent. was by contractors, and 52 per cent. by the day or on company's account: it produced about 2¼ tons of ore for each day's work.

The *wages* of the men employed in and about the mines, in 1869 and 1870, were about as follows: Common labor was nominally $1.80 per day for most of the time, but by far the largest part of the mining work was done under contracts. Contractors made, clear of costs, from $60 to $77 per month as high and low averages; $70 is probably near the mean of the whole. It was not uncommon for a "pair" (two or more men working jointly) to make $100 per month each, and again the earnings will fall so low as barely to pay board; but such are extreme cases. Leaving out the staff of the mine and the contractors, the wages of all others, mechanics, engineers, firemen, drivers, but mostly common laborers, averaged in 1869 and 1870 about $2.12 per man per day. Mechanics received from $2.50 to $4.00. In 1872 the wages of men and contract prices were from 25 to 50 per cent. above the figures here given.

The *nationality* at three mines, which employed an aggregate of over 600 men, was in 1870 as follows, expressed in percentages:

Irish..................................	31
English (Cornishmen).....................	27
Swedes.................................	18
Canadians (French)......................	5
Americans..............................	5
Germans................................	4
Norwegians, Danes, and Scotch............	10
	100

The relative proportion of the Irish element is decreasing; a few years since nearly all the men employed at some mines being of this nationality. The percentage of Cornishmen is increasing, owing largely to a want of work in the copper region. These men are skilled miners, and do a large part of the sinking and drifting. Swedes are rapidly gaining in numbers, many of them having been miners in their own country.

The exodus of Swedes to the United States apparently threatens to depopulate that country. There can be little doubt but that a more genial climate and better food will improve the lower class, from whom the emigrants come. Statistics of the population of the Upper Peninsula are given in App. G, Vol. II.

The unit of measure and comparison in the following table is the *gross ton of merchantable ore.* The ore is the object of the miner's efforts, and the tons sold measure his business. The items of cost in all that follows express the expenditure per ton of ore mined, prepared for market, and loaded on the cars. In instituting a comparison between these figures and those obtained by the civil engineer on public works excavations, where the cubic yard of vacant space is the ordinary unit of work accomplished, it must be borne in mind that the labor incident to sledging up and sorting out the ore from the rock considerably enhances the cost of mining.

In order to more intelligently follow the methods of working the Marquette mines, we must classify the various items of cost under appropriate heads, and assume some absolute cost per gross ton, as near the actual fact as possible, as a basis of comparison of these items with each other, and with other mining regions.

No discussion of the question which leaves out the *cost,* would possess much practical interest; but all who have undertaken to obtain such facts for publication, know the difficulty, and will not place implicit reliance on the accuracy of what follows. $2.64 per gross ton will be assumed as the entire cost of mining the hard ore, and delivering it in the cars ready for shipment (in 1870); but this sum does not include interest on capital, expense of selling, royalty or mine rent, nor depreciation of the mining property. The cost of mining the soft hematite ores is considerably less, and the methods much simpler.

Royalties or mine rents have not become settled; there are not many leased mines; one of the best of its kind (the New York) pays but 20 cents per ton for first-class specular ore. In other instances 75 cents is paid for a lean hematite. Time and experience will settle these prices on an equitable basis. See Atlas, Tables XII., XIII.

Before dismissing the subject of royalty or mine rent, which is not again noticed in the following discussion, I will make a few remarks. Marquette mines, as has been stated, are generally owned and worked by the same parties, hence royalty does not enter directly as an item of cost, but it exists in substance, and may be called *depreciation of the mine*, an item in the cost of ore often not sufficiently considered. One of the best organized and successfully operated iron companies in eastern Pennsylvania place this item at fifty cents per ton of ore. That is to say, every ton of ore sent from a New Jersey mine (which they own) is charged with fifty cents over and above its cost, as shown by the mine accounts, and a like sum is credited to the capital stock account, or to a sinking fund. This fifty cents stands for the original cost of the ore in the ground, and is all the more real, that it was paid in advance in the price of property and improvements. Any mining company which fails to recognize this principle is doomed some day to serious disappointment. Whoever has had experience with charcoal blast furnaces, which so rapidly sink their capital by the consumption of timber, will be fully alive to the importance of this matter. It is a delusion to suppose that our mines will not eventually be *exhausted;* iron ores do not grow; a ton shipped from a mine is gone forever, and the property has one ton less remaining, and is therefore worth less money. Continued shipments will eventually exhaust any and all deposits. Abandoned pits, in which no ore can be found, now exist at all of our mines, and in this class are some that two years ago were the best. The Andover mine, New Jersey, once presented as good opportunity to break ore as any pit now worked in the Marquette region; but about 150,000 tons aggregate product exhausted the mine, and to-day the owners do not know where to find a ton of merchantable ore on the property. I do not wish to be understood as predicting the exhaustion of the whole region; I think Marquette will produce iron as long as that article is wanted. New deposits of rich ore will be found, and leaner ones, which now have no value, will be worked, and the old deposits will be followed deeper; but this implies new mines, the building up of new locations, new railroads, new men and more capital. What I wish to say is, that unless present holders of average Lake Superior iron mining stocks are receiving fair interest on their investments, and in addition are being paid back the capital they have invested at the rate of, say, 50 to 75 cents per ton of ore sold, they are not doing a good business.

Therefore the $2.64 assumed in the following table should be increased by this royalty, making it $3.14. Commission for selling, interest and exchange, insurance and expenses of the general office of the company (including salaries), will increase this sum to at least $3.50, which will more truly represent the actual cost per gross ton of ore on cars and sold. This, from the amount assumed before as selling price, leaves from 50 cents to $1.50 per ton for interest on all fixed capital invested; in an exceptional condition of the market, like 1872 and 1873, the margins are of course larger.

There may be no better place than in this connection, to speak of another fruitful source of the disappointments which are sometimes experienced by stockholders. I refer to those delusive "*permanent improvement accounts*," better named permanent disappointment accounts, which are too often kept open, and in which are too frequently placed awkward sums which should properly go to running expenses, and be paid for by the pig-iron, ore, lumber, or whatever is produced. After the necessary real estate is bought, the mining or manufacturing plant built, and the business of production actually commenced, the improvement account should be closed forever. Some kinds of business, in some places, under some managements, may permit an opposite course, but the above is the only safe rule. If in any particular year an extraordinary expenditure is made which is not likely to be repeated, a part of it may properly be held in some open account, in order that it may be distributed over more than one year's product. But this is a different thing from piling up a permanent account under the delusion that the property is enhancing in value.

There are few kinds of business in which there is more danger from this cause than in iron mining, for not only is an iron-ore property depreciating from the exhaustion of the ore, but at any time it may be still more depreciated by unfriendly tariff legislation, for which the iron-master must be prepared.

TABLE *showing the Approximate Cost of Mining the Specular and Magnetic Ores of Lake Superior, made in* 1870.

General heads under which cost of mining is classified.		Elements of cost, not including royalty or depreciation.	Approximate cost of each item. In per cent. of the whole. Items.	Totals.	Based on a total cost of $2.64 per ton. Items.	Totals.	Amounts. Labor.	Supplies.
I. Dead work (preparation).		1. Explorations	00.6	28.1	.015	.742	Eighty per cent. .620	Twenty per cent. .122
		2. Sinking shafts	01.5		.040			
		3. Drifts and tunnels.	06.1		.160			
		4. Roads	00.6		.017			
		5. Stripping earth and rock	13.2		.350			
		6. Miscellaneous work and minor improvements*	06.1		.160			
II. Mining proper (labor).	Drilling.	1. Ledge holes (in stope)	04.2	39.8	.110	1.050	1.050	....
		2. Block holes (in fragments)	04.9		.130			
	Other work.	3. Sledging, sorting, and loading	13.3		.350			
		4. Handling rock	09.5		.250			
		5. Miscellaneous work	07.9		.210			
III. Mining materials and implements ("mine costs").	Explosives.	1. Powder and fuse.	03.6	11.9	.095	.313	.103	.210
		2. Nitro-glycerine	...†		...†			
	Tools.	3. Steel (drills)	00.7		.018			
		4. Tools other than drills	01.6		.043			
	Repairs.	5. Blacksmiths' supplies	01.8		.047			
		6. Blacksmiths' labor.	04.2		.110			
IV. Handling ore from miners' hands to cars, and pumping.	By horses.	1. Teaming, labor of drivers and stablemen	05.7	15.6	.150	.413	.272	.141
		2. Forage	04.2		.110			
		3. Carts, sleds, harness, etc.	00.2		.006			
	By men.	4. Loading ore from stock pile	01.3		.035			
	By steam.	5. Labor, supplies, and repairs	04.2		.112			
V. Management and general expenses.		1. Salaries and office expenses. 2. Tax of all kinds.	04.6	04.6	.122	.122	.062	.060
			100.0	100.0	2.64	2.64	2.107	0.533

* Does not include exceptional permanent improvements.

† No reliable figures obtained.

In order to institute a comparison between American open-excavation mining and the systematic underground work of Sweden, I append the following table, for which I am indebted to Prof. Richard Akerman, of Stockholm :—

COST OF MINING ORE IN PERSBERG MINES, SWEDEN, 1870.

In currency.

General heads under which cost of mining is classified.	Elements or items of cost, not including royalty or depreciation.	In percentage of whole. Items.	In percentage of whole. Totals.	Based on a total cost of $2.20 p. ton. Items.	Based on a total cost of $2.20 p. ton. Totals.
I. In the mine	1. Boring	22.73	38.66	.50	.85
	2. Powder	5.82		.13	
	3. Priming reed	0.84		.02	
	4. Clay	0.50		.01	
	5. Candles, augers, and sledges	2.33		.05	
	6. Charcoal	0.44		.01	
	7. Auger whetting	3.20		.07	
	8. Shooters' fees	2.80		.06	
II. Water drawing (or pumping)	1. Water drawing	3.50	3.50	.07	.07
III. Bringing up the mountain (hoisting rock and ore)	1. Putting into the ton	4.68	11.17	.10	.26
	2. Receiving	1.11		.03	
	3. Down freight	1.10		.03	
	4. Hoisting	2.74		.06	
	5. Oil and lines	0.28		.01	
	6. Mine tubs and ladders	1.26		.03	
IV. Dressing	1. Dressing	8.12	8.12	.18	.18
V. Picking and washing	1. Picking and washing	5.65	5.65	.12	.12
VI. Buildings	1. Buildings	16.45	16.45	.36	.36
VII. General expenses	1. General expenses	16.45	16.45	.36	.36
		100.00	100.00	2.20	2.20

Professor Akerman furnished also these explanations :—

a. Our drill holes are about one inch in diameter and cost 7½ to 12 cents currency, per foot, when boring downwards, and twice as much when boring upwards.

b. Powder costs 11½ cents, dynamite 43 cents, and ammonium powder 40½ cents per Swedish pound (the Swedish lb. equals .93 of the English).

c. The reason why blasting with us is more expensive than with you, must partly depend upon stronger mountain ground and partly upon the small diameter of our augers.

d. "Dressing" on the Persberg table is to be understood as sledging and sorting.

e. "Picking and washing" is a kind of after-sorting by hand of the smaller pieces (of which about a third of the ore consists), got partly by blasting and partly by the first sorting.

f. "Buildings" include timbering in the mines and all buildings made for pumping and hoisting.

g. "General expenses" include some benefits for the laborers, such as domiciles, potatoes, gardens, expenses for schools, medicine, administration, etc., etc.

h. "Down freight" is the cost for bringing down the ore a short distance from the mines to the lake-shore, where it is sold.

i. Water power is used at Persberg both for pumping and hoisting.

j. Our miners receive from 48 to 75 cents per day, besides what I above called benefits.

k. The mining costs at Persberg are among the highest in Sweden.

The titles of the several heads under which mining costs may be divided, and the number of the items, depend on the object sought : the classification employed in the Marquette table, seemed best adapted to the presentation of the facts in hand. It will be observed that the form of the Swedish table differs materially and is of course better adapted to underground work, and to a more careful and laborious selection of ore.

I believe that considerable advantage would accrue to many of the Marquette mines, if the accounts were so kept that cost sheets similar to the foregoing could be prepared from time to time. It is well known that the cost of mining varies greatly in the different mines, some costing twice as much as others. This difference is often largely owing to natural causes, but sometimes it is, in part at least, in the management. There is no better way, in fact there is no other way, of stopping "leaks" of this sort, than by first finding where they are.

A comparison of such cost sheets from different mines, for the same time, or from the same mine for different periods, would indicate at once to which items the excessive cost belongs, and thereby direct the attention of the management to the leak. I therefore venture the opinion, that a carefully prepared cost sheet is one of the first steps in attempting to reduce the cost of ore.

In the detailed description of methods which follows, the items will be taken up in the order of the table.*

I. Dead Work.

This general head embraces all the work and costs incident to getting ready to mine the ore, and is subdivided into—1. Explorations (embracing only such searches for ore as are in progress from year to year about the mine). 2. Sinking shafts. 3. Drifts and tunnels. 4. Roads for wagons. 5. Stripping earth and rock, or uncovering the ore. 6. Miscellaneous work and minor improvements. The entire expenditure for dead work is 74 cents per ton of ore produced, which equals 28 per cent. of the whole cost.

1. **Explorations.**—More or less digging of test-pits, sinking shafts, drifting, trenching, and sinking drill holes is constantly in progress at most of the mines. My facts indicate that this work varies in amount from one-half to three cents per ton at the producing mines, being of course greatest at the new locations. It is not carried on systematically, being pushed when there is an increased demand for ore, or some old pit shows signs of failing, and again entirely discontinued. The price paid for pits 4 feet by 6 feet, and not over 10 feet deep, is from 30 to 60 cents per foot, depending on the ground; when so deep as to require a windlass, 50 to 75 cents and up to $1.25, if the shaft reach the depth of 30 feet and is wet. Drifting in firm earth will cost about the same per foot, depending

* For detailed descriptions of all the mine workings as they were at the close of the season of 1872, see "Appendix to A. P. Swineford's History of the Lake Superior Iron Region," being a review of its mines and furnaces for 1872, published by the Marquette Mining Journal.

on the depth below the surface and nature of the earth. Drill holes sunk by hand, material 15 feet deep, will cost from 75 cents to $1.00, and if deeper, considerably more per foot. There seems to be no reason why more use should not be made of the drill in this work. By means of a simple spring pole, such as was used in early days in the oil region, holes could be easily sunk 100 feet, which is as deep as it is usually necessary to go at this time. An experienced miner will judge very accurately of the ground passed through by the mud, and if there was any doubt, chemical analysis would determine the nature of the material; the mud furnishing a strictly average specimen, so desirable in an analysis for practical purposes. As has been mentioned, the *annular diamond drill* was introduced last season (in 1869) at the Lake Superior mine with success. A hole 130 feet deep was sunk at a cost of about $5 per foot; the core produced furnished very satisfactory knowledge of the substance passed through. The drill did not perform as well at the Washington mine, where several holes were sunk, the deepest 96 feet. In two instances the annular diamond bit got fast in an oblique seam and two were lost; not counting loss of diamonds, the work cost about $1.50 per foot: whether larger bits, a different setting of the diamonds, or more experience would overcome this difficulty, I do not know. It is a matter of great importance, and is worth thoroughly working out. As the subject of exploration for ore has been fully considered in another chapter, it is not necessary to treat it farther here.

2. **Sinking Shafts.**—This work, which forms so large an item of cost in some underground mines, varies in the Marquette Region, so far as I have ascertained, from 1½ to 5½ cents per ton of ore. Our open and comparatively shallow workings do not call for many shafts or winzes; the deepest shaft in the region is now (1870) not over 200 feet. The prices for this work range from a mean of $22.50 to $31.50 per foot in depth, depending on the hardness of the ground. In some mines, extreme prices range from $15.00 to $40.00, and even more if the shaft be very wet. Miners are often permitted to select the size most advantageous to themselves, which may be four feet by six; but eight by twelve feet is more common. The material is generally hoisted with the ordinary hand windlass, but sometimes with a horse-whip or whim, the miner having to deliver the stuff at the mouth of the shaft. From 10 to 15 per cent. of the

price received by the miner for sinking has to be expended in *mine costs; i.e.*, powder, fuse, candles, steel, tools, etc. No charge is made against him for smith's work. Sometimes the contract is let at so much per foot of shaft and so much per ton of ore, which gives the miner an interest in separating ore from rock.

3. **Drifting and Tunnelling.**—This element of cost varied more widely than any other, and might have been divided into two: (1) Drifts designed to open ground for stoping; and (2) Tunnels or adits for drainage and transportation of ore, the latter being of the nature of a permanent improvement. But on the principle that permanent improvement accounts are often permanent disappointment accounts, and to be avoided, and considering the fact that this kind of work is actually going on year by year, and must do so as long as the mine is worked, it does not seem wise to separate it from the current cost of getting ore. Ordinary 4 × 7 drifts cost, in hard ore, from an average of $22.50 to $24.50 per foot, the miners delivering the material behind them, and paying their own costs, as in the case of shafts.

Tunnels large enough to admit railroad cars and small locomotives cost from $30.00 to $50.00 per foot. The Washington tunnel, now over 1,100 feet long, and timbered a considerable part of the way, cost an average of about $40.00, not including rails. The timbered portion is twelve feet wide at the bottom, ten feet at the top, and ten feet high in the clear. No machinery has yet been brought to bear on either sinking shafts or drifting; the labor required is more than one-half expended in drilling holes for blasting. The subject of drilling is fully considered under its proper head.

4. **Making Wagon-Roads.**—The great amount of team-work employed about the mines requires a complete system of roads for summer and winter use. These are sometimes expensive on account of rock-cuts, costing, in some instances, as high as four cents per ton of ore in the early stages of work.

5. **Stripping Earth and Rock,** or uncovering the ore. This constitutes on the average nearly one-half of the dead-work, and is one of the largest single items in the whole cost of mining. So far as my inquiries extended I found it to vary from 20 to 52 cents per ton of ore. This cost is necessarily increasing at all of the mines worked as open cuts. It is simple rock and earth-work, the material being removed on wagons, carts, or sleds, drawn by horses.

The advantages of light railroads and small locomotives do not seem to have commended themselves for this work. There would, of course, be considerable danger of destroying tracks from blasting, and it often happens that not much work has to be done in one place; still there is no doubt but that a large saving would be effected by substituting steam for horses in portions of this work, as will be more fully considered hereafter.

The aggregate amount of material which has been handled in stripping is very great. Thirty and even forty feet of earth have been removed, and nearly as great a depth of rock; but this is the experience in open workings everywhere. I have seen twenty-one feet of earth and soft, shaly rock stripped from a nearly horizontal bed of 44 per cent. Clinton ore in Western New York, which did not average over thirty inches thick. In South-eastern Kentucky I found the rule among the miners of sub-carboniferous ores to be, that it would pay to remove a foot of earth for the sake of an inch of ore, which does not differ widely from the Western New York practice. In both of these instances the stripping was nearly the entire cost of mining, and labor was much lower than in the Marquette region. The usual contract price for removing ordinary earth (sand, clay, and boulders mixed together) is fifty cents per cubic yard, the digging costing about one-half, and the hauling one-half. Hauls vary from 100 to 800 feet. The highest price paid for excavating any considerable quantity of rock in open cuts, which has come to my notice, was $3.00 per cubic yard, equal to $24.00 per fathom, or about $1.00 per ton. This was a very hard jasper rock, containing but little ore. Large quantities of rock have been excavated and hauled over 500 feet at the Lake Superior mine for $2.50 per yard. The soft greenish schist, so common at all the mines, can be moved for from $1.00 to $1.40 per yard, including hauling. When a good face can be obtained on the overlying quartzite, which is likely to constitute the greater part of the rock to be moved in future, it should be broken down and loaded on wagons for from $1.50 to $2.00 per cubic yard.

The amount of money which it will pay to expend in stripping of course depends chiefly on the quantity of ore uncovered. If we assume fifty cents to be the maximum expenditure per ton of ore for this work (this amount has been greatly exceeded), the problem of what thickness of rock may be stripped admits of an easy theoretical solution. One cubic yard of solid ore (allowing for wastage on account of associated rock) may be considered to yield three tons of merchantable ore, which, at the allowance above assumed, would give us $1.50 to be expended per square yard in stripping a bed of ore only one yard thick. Hence in this case it would pay to remove nine feet in thickness of earth, or about three feet in thickness of rock. But suppose we have a bed of ore twenty-four feet in vertical thickness, which is a more common case, what amount of earth or rock would it pay to remove under the assumed limit of expenditure? Twenty-four feet of ore will yield twenty-four tons per square yard of surface, which, at fifty cents per ton, gives $12.00 available for stripping per square yard. This sum would remove twenty-four feet thickness of solid rock; or a foot in thickness of rock may be stripped for every foot in thickness of ore uncovered, at a cost of fifty cents per ton of ore. The same expenditure will remove three times this thickness of earth.

An important and often neglected question connected with this subject is, *where to deposit waste*, that it may be out of the way of future mining operations. Some material has been already handled twice in the Marquette region, and I know of a mine in Southern New York where the same earth was three times handled before it was finally permitted to rest. In a new region, like Marquette, where comparatively little thorough exploring has been done, it is often difficult to decide where waste piles will be out of the way for all future time. If a drill hole were put down for fifty feet in rock, and no ore found, it would be safe to say, that if ore existed under that spot, it would have to be mined under ground; hence, that so far as future stripping was concerned, a waste pile placed there would be out of the way. A very common practice in under-ground work, in some mining regions, is *to fill up the worked-out places with the waste*, and this can undoubtedly be done to advantage in some instances in open works, although it has not as yet been practised in the Marquette region. The trouble is to find out when a pit is exhausted—it is so common to break through a thin layer of rock and find a bed of workable ore behind it. But there are parts of most mines where the foot-wall has unquestionably been reached, and if any doubt exists, a few deep drill-holes will settle the point. When this is the case, and the foot-wall has a sufficiently gentle slope to permit of its holding materials deposited on it, it will, I think, be often found advantageous to use it to support a waste pile.

For the sake of illustration, take the New York and Cleveland Mine workings, which are adjacent. In this instance the slope of the foot-wall is so steep that it would probably be necessary to cut in it a rude step on which to rest a rough retaining wall, which could be built of blocks of quartzite swung across from the hanging-wall by means of a derrick. The triangular space thus formed would hold all the waste rock for a long time to come, and would afford a minimum haul. It might not answer to deposit earth in such positions, as heavy rains would be likely to wash it into the pits. The dip of the foot-wall in this, as well as in most cases, will, I think, become flatter in depth, so that a better opportunity will be afforded for a second similar waste receptacle at greater depth, if one should be required.

6. **Miscellaneous Dead Work.**—Under this head are included several items which were not of sufficient importance to require separate treatment. Improvements such as dwellings, shops, fences, tracks, trestle-works, pockets, docks, whims, skip-ways, pumping-fixtures, etc., etc., occurring from year to year, are embraced here. These items are in part embraced under "Building" in the Swedish table. This head was originally also designed to cover those exceptional expensive improvements which are of occasional occurrence only, and the cost of which might properly be distributed over several years' product. Additional facts, however, lead me to believe that the amount given (16 cents per ton) is too small. The expensive pumping and winding plants now being erected, and which will continue to be built for a long time to come, increase the cost of the ore materially unless we charge them to permanent improvement accounts, which is not altogether a safe course, as has been already pointed out.

II. Mining Proper, or Breaking Ore.

This general head embraces all the labor incident to blasting the materials down from the solid ledge, breaking it up into fragments that may be easily handled, the separation of the ore from the rock by hand and loading. The average cost of this is $1.05 per ton of ore produced, which equals forty per cent.

of the whole. The character of this work will be sufficiently well understood from the table and the following explanation :—

1. **Ledge or Stope Holes.**—The drilling or rock-boring is now (1870) entirely done by hand. The steel used for drills is 1¼ inch octagon, with a bit 2 inches, making a hole nearly 2¼ inches in diameter. Drills vary in length up to 24 feet. English steel is used at some mines, but a majority use American steel, and the most experienced men who have employed both, inform me that the drill steel made by Hussey & Wells and Parke Bros., Pittsburgh, answers as well as the best imported steel, and much better than the average. The drill is turned by one man sitting and struck by two standing, with eight-pound hammers, at the rate of about thirty-six blows per minute each. In this way from nine to eleven feet of hole are sunk per day, the men working usually on contract. The price of stope holes ranges from 60 to 80 cents per foot in depth, the mean being not far from 75 cents ; no mine costs have to be paid out of this price. When there is a large proportion of block holes, which admit of the use of smaller steel, the whole drilling of a pit is often let at from 60 to 65 cents. Very deep holes, say from fifteen to twenty-two feet, are sometimes sunk with still larger bits, which about doubles the cost. In these cases two men are required to turn the drill and three to strike.

The cost of drilling ledge-holes per ton of ore, varies from a mere trifle in the case where one twenty-two foot hole throws down 4,000 tons, as has been done, to a very large item on low stopes with perhaps tight, hard ground. From 3 cents to 25 cents per ton may be regarded as extreme averages, although 35 and even 48 cents have been reached, for short periods, under very unfavorable circumstances. The price given in the table (11 cents) approximates to the average for hard ores ; this number divided into 75 cents, the average cost of drilling per foot, gives, say 7, which should represent the number of tons of ore broken per foot of stope-hole drilled. The data obtained directly under this head confirm this amount, which is also equivalent to about two cubic yards per foot of hole.

The depth of stope-holes varies from two to twenty-two feet, the short ones being employed in "taking up bottom," that is, in squaring the stope so as to give the best chance for the deep holes. The average of 1,500 holes of all kinds in one part of the Washington mine was four feet nine inches, but the stopes which furnished this result were below average height. It is believed that nine or ten feet would be nearer the average for deep holes, and say three and a half feet for the short ones.

2. **Block-Holes.**—The masses of rock and ore loosened by the heavy blasts already described, are often so large that they have in turn to be broken with explosives, which operation is termed block-holing. The amount of this work varies from almost nothing in some pits and in certain mines, to four-fifths of all the drilling required in others, the maximum being reached on high stopes of hard, tough ore. Over two hundred block-holes have been employed to one stope-hole in the Cleveland Mine, one hole being required to every two to four tons of ore. Block-holes sometimes produce fragments so large as to require block-holing in turn, before they are made small enough to be mastered by the sledge. These holes vary in depth from eight to twenty-four inches, the mean ranging near one foot. With nitro-glycerine the holes need not be so deep as for powder. One inch octagon steel is often used in this work, making a hole nearly 1½ inches in diameter. The drilling is performed as in the case of stope-holes, but usually only one man strikes.

In the same ground, the same drill-gang will sink more than twice the number of feet of block-hole in a day with small steel, than of stope-hole with large steel,—ranging from twenty-four to twenty-seven feet. In open mines of strictly hard ore, this work costs more than stope-holes, and is set down in the table at 13 cents per ton. This amount added to the 11 cents given as the cost of stope-holes per ton, equals 24 cents for the total cost of the labor of *drilling* required under breaking ore :—this would also equal about 70 cents per cubic yard, which would pay for one foot of two-inch drill-hole. But this is by no means the whole ; the work of sinking and drifting, which is set down as aggregating 20 cents, is more than half drilling ; and a part of the cost of rock-stripping is also for this work. I estimate that 40 *cents per ton of ore* is not far from the actual price paid for this kind of labor in the hard-ore mines, equal to fifteen per cent. of the whole cost. On this estimate, not less than $300,000 were paid out for drilling in 1870. This work, from the favorable circumstances under which much of it is done in open excavations, no scaffolding being required, is by far the most purely mechanical labor performed about the mines. While the absolute cost of this item of drilling is very large, and can undoubtedly be reduced by the use of the *power-drill*, it is, as compared with some other mines and regions, small. Our open cuts or quarries afford far better facilities for blasting than under-ground mines. In one Southern New York mine the drilling cost, in 1870, $1.25 per ton of ore, o · forty per cent. of the whole cost of mining; in a large magnetic mine in New Jersey, it cost from 60 to 80 cents per ton of ore. In the Persberg mines, Sweden, when the ore cost, in 1870, $2.20 currency per ton, the drilling was 40 cents per ton, equal to twenty-three per cent. of the whole cost, being considerably more than ours, absolutely and relatively. When we consider that the average of wages in Sweden is not far from 65 cents per day, or say one-fourth of what is paid Lake Superior miners, it would seem as if Sweden would be a good field for a power-drill.

The facts relating to drilling have been given in much detail in the hope that inventors and owners of rock-drilling machines may become acquainted with the wants of the Marquette region in this regard. I have had my attention called to several of these machines, but have not had opportunity to make such investigation of their respective merits as would justify an opinion. I have no hesitation in saying that a machine which would do the work required at a less cost than it is now done (75 cents per foot) would find ready sale, and every facility would be afforded for experiments.

I need not here remark that a power-drill, adapted to Marquette iron mines, must be portable, as it would have to be shifted every few hours; and I should say that two men, or at most three, should be able to handle it on a ragged rock surface. Again, it must be capable of being set up anywhere, to accomplish which, I think that movable tripod, telescopic legs, like those with which engineers' instruments are often supplied, would be convenient.*

3. **Sledging, Sorting, and Loading.**—In considering this item, it must be borne in mind that the ore and rock have not only to be broken so that they can be removed, but must be made so fine as to

* Since the above was written the Burleigh Drill has been tried at several mines with varied success. My facts are quite insufficient to enable me to form a judgment as to its fitness to do the required work, or to know whether it has had a fair trial.

be easily separated, and so that the pieces can be fed into a Blake crusher. This work requires more muscle and as much skill and care as any other done at the mine. Eighteen to twenty-three pound sledges are employed, and the difference in results, between the experienced miner who strikes the lump of ore the right blow in the right place, with this immense hand hammer, and the tyro, is very great. Contracts for sledging and loading, which sometimes include a little block-holing and short tramming, have been let at prices varying from 20 to 50 cents per ton. The loading usually costs not to exceed 10 or 12 cents, the balance being chiefly sledging. There is a wide difference in the texture of ore, some kinds requiring five times as much sledging as others. On the whole, Marquette ores break with much greater difficulty than those of the Eastern magnetic mines. With poorer ground worked and the market more in favor of buyers (which makes them more exacting on quality), the cost of this element will be increased.

Drops, similar to those used at foundries to break old castings, have been employed to break very hard lumps of ore, but the expense of getting the lumps of ore to them has caused this plan to be abandoned. In the copper region powerful steam hammers have been used for a similar purpose, but the same objection as that given above would apply to their introduction at the iron mines. It must be borne in mind that a lump of iron-ore is not worth more than about one-hundredth part as much as a lump of copper of the same weight, and therefore will not bear as much handling.

A steam miner who can walk up to the lump of ore and sledge it to pieces where it lies is what is wanted. Nitro-glycerine or duallin breaks the material finer, producing by its explosion more of a smashing effect than powder, and thereby requiring less sledging. There is no doubt, as is elsewhere stated, about the advantage of employing these new explosives in block-holing.

4. **Handling Rock.**—In addition to the rock which overlies the ore, considered under stripping, at most of the mines more or less rock is found mixed with the ore through the mines, which has to be removed during the process of mining. The proportion varies from none up to one-half of the whole, and often for short periods more than this; the average at this time is believed to be twenty per cent. The 25 cents placed against this item in the table is intended

to cover the cost of sorting out and handling this rock under average circumstances. This cost will be increased as poorer grades of stuff are worked.

5. **Miscellaneous Work.**—The 21 cents opposite this item in the table is no more than sufficient to pay for foremen, repairs of tracks and roads, wheeling, tramming, blaster, sometimes hand-pumping, and such securing of the workings as may be necessary, etc.

III. Mining Materials and Implements, embracing "Mine Costs."

This general head is subdivided in the table into Explosives, Tools, and Repairs, which are in turn itemized, as will appear below. The expense incurred here is 31⅓ cents per ton of ore produced, equal to about twelve per cent. of the whole cost.

1, 2. **Explosives.**—Powder and fuse and nitro-glycerine. The present (1870) is an unfortunate time to collect statistics regarding the cost of explosives, for the reason that nitro-glycerine is to a certain extent on trial, and most of the mines employ both it and powder in the same pits, making it difficult to separate the results. The place of the new explosive cannot be said to be wholly fixed in our mines. It is more powerful than powder, bulk for bulk, or weight for weight; can be used in wet as well or better than in dry ground, which is very important in some places; it has so far proved no more dangerous than powder, and its fumes have not been found objectionable. As has been stated, the fragments resulting from its use are usually smaller, hence require less sledging, and, it being more powerful than powder, less drilling is needed.

In the case of wet holes intended for sand-blasting, nitro-glycerine can often be used in small charges to produce cracks which carry off the water and thus prepare the way for the powder. Overhanging loose rock can often be advantageously brought down by a flat cartridge of glycerine.

In short holes, 3 to 6 feet, glycerine will sometimes break two or three times as much ground as powder, thus making the saving on the drilling more than balance the extra cost of the explosive.

The quantity of glycerine used per hole, of course, varies with its

depth and other circumstances, and is at the Washington and Republic Mines, according to Captain Peter Pascoe, as follows :—

Depth of hole.	Glycerine.
3 feet	¾ lbs.
4 "	1½ "
5 "	2¼ "
6 "	3½ "
8 "	5 "
10 "	7 "
12 "	10 "
14 "	14 "
16 "	18 "
18 "	21 "
20 "	24 "

There can be no doubt but that the use of this explosive hastens work. Sinking and drifting can be more speedily done with it than without.

Whether it is suited to breaking the great masses from the solid ledge remains to be seen. Certainly it cannot be used to fill the cracks produced by shaking, where heavy sand blasts are required; and it is doubtful whether drill-holes large enough to contain the requisite amount of the blasting oil can be profitably employed; two or more holes could be used, but this would greatly increase the cost of drilling. It certainly costs *more* per ton of ore mined than powder, but how far this greater cost is balanced by other advantages experience must determine. It is significant that in 1870, being the next year after its introduction, over $40,000 worth was sold in the Marquette region at $1.50 per pound. In 1872 about 40,000 pounds were used, the price being $1.25 per pound. The Painsville Ohio Co. erected (1871) a factory near Negaunee. Duallin and giant powder have recently been introduced.

The figures given in the table, and in what follows, refer exclusively to powder, the nitro-glycerine element having been eliminated as far as was possible. Fuse costs about ½ cent per ton, leaving 9 cents per ton for powder, which, according to the data obtained, varied from 7 to 10 cents. The price of powder ranged from $3.75 to $4.50 per keg of 25 pounds. Therefore an average of 45 tons of ore should have been broken with one keg of powder, or about ½ pound of powder to one ton of ore. This, it must be remembered, does not express the actual work of the powder, on account of the amount of rock moved in addition to the ore—in one instance 23,000 weighed tons of material required 320 kegs of powder, or 72 tons per keg. In another instance 31 kegs threw down 3,500 tons (approximate) of quartzite, or 113 tons per keg. One mine, which produced over 100,000 tons of ore in 1869, consumed for all purposes one keg of powder to every 43 tons of ore produced. The waste material in this case did not amount to over 20 per cent., hence about 52 tons, or, say, 18 cubic yards of material, were moved per keg of powder. The consumption of explosives per ton of ore must increase as the mines grow deeper, either by the greater amount required to remove the rock covering, or by the less favorable opportunity afforded for blasting, if the ore be won underground.

In one group of New Jersey mines, the powder and fuse in 1870 cost 18 cents per ton; in another mine in Southern New York, 14½ cents; in Sweden, at the Persberg mines, 15 cents. All of which figures considerably exceed those reached in Marquette, which is proof of the economy in explosives from working iron mines as open quarries as long as possible.

3. **Steel.**—The use of steel drills has already been described, and reference made to the brands in use. My data, which are far from complete, under this head, indicate that the cost of steel per ton of ore ranges from ¾ to $3\frac{3}{10}$ cents, averaging perhaps $1\frac{8}{10}$ cents; the price of steel being 20 cents per pound. This would give about 11 tons of ore, or about 3 cubic yards per pound of steel consumed, which is less than the data obtained direct on this point seemed to indicate.

It is the practice of some mines to charge the ore contractors 2 per cent. on their contracts for wear of steel, which agrees nearly with the above. At other mines the steel is weighed at the end of each month, and the contractor charged with the shortage, whatever it be.

4. **Tools, other than Drills.**—Cost about $4\frac{3}{10}$ cents per ton of ore.

The Ames No. 2 D-handled, square, and round-pointed, strap-backed, solid steel shovel is the favorite.

Washoe picks, Nos. 5 and 6, and Powell, same numbers, both railroad (25 inches long), and pole (19 inches long) are extensively used. Certain mines make their own picks after a fashion of their own.

Solid steel crow-bars, both single and double-pointed, are used.

Solid cast-steel sledges, both American and chrome, weighing from 16 to 18 pounds, and often 25 lbs., are extensively used.

Solid cast-steel striking-hammers, 8 to 9 pounds, and in some instances 11 pounds, are employed.

5. **Blacksmiths' Supplies.**—This item is largely made up of coal and iron, steel being embraced under another head. Charcoal was formerly used exclusively for working steel; but mineral coal is now employed with good results at most mines. The table shows this item to be a trifle less than five cents per ton of ore.

6. **Blacksmiths' Labor.**—This is largely sharpening drills. The number dulled per day by a gang of three drillers will average about 75, in hard ore. One blacksmith and helper will sharpen about 275 drills per day of ten hours. The 11 cents marked opposite this item embraces all the blacksmiths' work done in and about the mine, for whatever purpose. Therefore strictly, it should have been divided, part going to dead work.

IV. Handling Ore from Miners' Hands to Cars, and Pumping.

Pumping, which has heretofore been a small item in the Marquette region, cannot well be separated from hoisting ore, as the same machinery does both. This item, in the case of some New Jersey magnetic mines, costs 75 cents per ton of ore: at the Persberg mines, Sweden, it costs but 7 cents. The entire cost under this head, in the Marquette region, including hoisting and pumping, is 41 cents per ton of ore produced, which equals 15½ per cent. of the whole. This work is done in part by horses, part by men, and part by steam.

1, 2, 3. **The Work of Horses in Handling Ore.**—The team work employed at the Marquette mines, apart from the stripping, amounts, according to my inquiries, which have been quite full on this point, to 10 per cent. of the whole cost of mining, or say 27 cents per ton of ore, the drivers' wages being the largest item. This cost is obtained by dividing the total expenditure for teaming, by the total number of tons of ore produced. If it was figured only on the ore actually handled by the horses, it would be much greater. If to this were added the cost of the team-work employed in stripping, the total would not be less than 30 cents per ton of ore, or, say $250,000 on the product of 1870, a sum sufficient in itself to supply all the mines in the region with all the additional steam-hoisting and pumping machinery and small locomotives required to do the work now done by horses, and at a very much less yearly cost. We may verify this almost incredible estimate in another way. The total number of horses employed at all the mines in 1870, including hired teams, was about 364, or an average of 30 to each mine, varying from 9 to 74. The best data I can get indicate that to work a lot of horses for one year, including wages of drivers, stable-men, smiths' work, forage, repairs of vehicles, and depreciation, in the years 1869 and 1870, cost an average of $650 per horse. The wages of hired teams, including drivers, for the same period, was $6 per day. At this rate, 364 horses would have cost nearly $240,000, a sum sufficiently near the other to confirm the general truth of the estimate.

These figures surely justify the prediction, that if there ever comes a period when our mines do not pay, it may be due largely to horses. In this age of steam, has a business any just right to prosper which employs horses to do work that can be more cheaply done by machinery? The average number of tons of ore handled per horse employed in and about the mines for all work in 1870 was 2,350, ranging from 1,150 to 5,300 tons. In considering these facts it must be borne in mind that the mines in question are not by any means without steam power. Twelve engines, varying in power from say 10 to 50 horse, were at work. To prove that this item of cost is unusually large in the Marquette region, I will give a few facts regarding the employment of live stock at mines, which have come under my notice elsewhere. While the cases cited do not present all circumstances like the Marquette mines, they are sufficiently near to afford interesting comparisons.

The Cornwall Ore Bank Co., Penn., shipped from their one immense deposit, in 1870, over 174,000 tons, employing no horses in the work. The ore was all handled by one locomotive, the cars being loaded by wheelbarrows. No pumping is required in this mine, and the facilities for reaching the ore with cars are unusually good. The ore is quite soft, so that the blasting does not endanger the tracks.

The Iron mountain mine, Missouri, shipped in 1870 more ore than any one mine in the Marquette region. It employed during the winter 68, and during the summer a somewhat less number of horses, mules, and oxen. One animal moved about twelve tons per day, or 3,600 tons per year; but more than three-fourths of this stock was employed in getting "surface ore," a feature which does not exist in Marquette mining. The bluff (quarried) ore moved per horse employed was more than five times the above amount. No steam-engine or locomotive was in use at the mine.

At the Caledonia and Keene mines, St. Lawrence County, New York, in 1869, three horses handled 27,500 tons of ore and waste, the average haul being over 700 feet, all up grade, in places steep. This gives over 9,000 tons per head; steam was not employed for handling material at either mine.

The Sterling mine, Orange County, New York, shipped in 1869 40,000 tons of ore, which was handled under circumstances quite similar to those encountered in the Marquette region, by two horses and one small stationary engine, which gives 20,000 tons per animal employed. The system of tramways and sidings at this mine is very complete.

Passing from American to Swedish mines, which are far deeper, and in which there is a larger percentage of rock mixed with ore, we find that in the Persberg mines, in 1870 (see table), the total cost for handling ore and water drawing was 14^2 per cent. of the whole cost, or 33 cents per ton of ore; and this amount included the handling of all the rock and other waste material which in our table is embraced under *Dead-work*. If we take out of dead-work 10 cents for handling this waste and add it to the amount found above, we have 51 cents as total cost of handling Lake Superior ores, equal to twenty per cent. of the whole cost, or about fifty per cent. greater than in the Swedish mines, but there water was exclusively used.

It is not difficult to understand how *horses** have come to play so important a part at our mines.

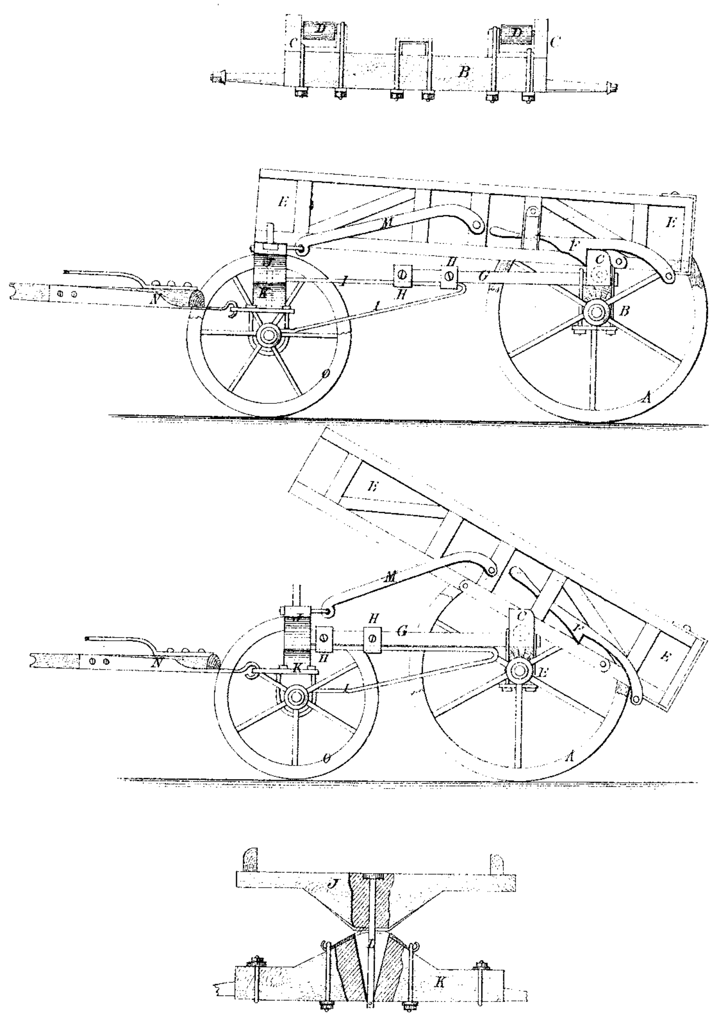
* It should be noted that oxen have been in use for some time at the Lake Superior mine, but, so far as I am informed, at no other.

The first operation in opening a new mine is, usually, to strip off the earth and rock covering, which can be best accomplished with the horse and cart. On the ore face thus exposed, mining is begun, the ore being hauled to the cars (often not brought very near to the pit), and such rock as is mixed with the ore is sorted out and hauled in another direction. It is very convenient and economical to back a cart directly to the miners' hands, and this was done until it came to be regarded as *the way* to get out ore. There was certainly no better way at the start in many cases; but when horses come to be used on hauls of over 500 feet and up grades, in places as steep as 1 in 10, the operation costing 25 to 30 cents per ton, it may be worth while to ask if such ore had not better be left in the ground until machinery propelled by steam can be brought to bear on it. Another cause which conspired to prolong this expensive mode, was the great demand for ore during the war and the consequent high prices. Mine superintendents were given no time to plan nor make improvements looking to future economy. Mine owners did not then want surveys, nor machinery, nor tunnels, nor anything that had reference to the future; they only wanted ore, nor did they care much what it cost, nor what the quality was (so consumers say): it was ore, ore, ore! Wherever three men could be set at work, a cart was backed up to them and shipments began from a new pit.

On short hauls, smooth roads, and light grades, horses can be used to advantage, and will continue to be so used, especially where there is more or less uncertainty as to the quantity of ore in the pit worked, which is often the case. But where there is a large mass of ore, rock, or earth to be moved under any other circumstances, it will usually pay to bring steam-power to bear upon it. Portable, or easily-to-be-moved railroads, and small locomotives for long hauls are in much favor at this time, and would have the advantage of utilizing existing wagon-roads. But the first step in many cases is undoubtedly to lay horse railways on the present roads. As is shown above in the remarks on the use of horses in certain New York iron mines, one animal can move from ten to twenty thousand tons on such roads in one year. If the horses at our Marquette mines can be made to perform one-third this amount of work, the present cost of hauling will be reduced fifty per cent.

Portable hoisting-engines are extensively used in New Jersey and

Pl. XVII.



WILLSON'S DUMP WAGON.

Pennsylvania; they can be set up quickly just where wanted, and handle material rapidly and with great economy. A thorough system of under-ground communications which would bring all or most of the material to the main hoisting-shaft is always to be aimed at, as in this way the dead lift may be made by steam. At present, owing to the continued pressure for ore, it is not uncommon to see ore and rock carted up-hill, over abominable roads, from pits which in a few months, perhaps, will or could be reached by drifts along which the ore could be cheaply trammed to a steam hoisting-shaft.

As may be supposed, this extensive use of draught animals has led to great perfection in the carts, wagons, and sleds. A dump-sled for winter use, contrived by Captain Merry, of the Jackson mine, is a perfect vehicle of its kind. I am unable to give drawings of but one, known as Daniel Willson's Patent Dump Wagon, of which over 50 are in use in the region. See Plate XVII.

While harnessed to the cart or wagon is the favorite mode of using the horse, it is by no means the only way. Some pits in the course of mining became too deep for cart roads; these were in many instances worked by *swing derricks*, horses being the power employed; the long booms of these derricks made it possible to drop the bucket in different parts of a wide pit. This method is, however, very expensive, as the following figures will show. The total lift from bottom of pit to bottom of cart was in one case 79 feet; the cost being as follows:—

2 men filling	$4 00
1 man to land	2 00
2 derrick horses and driver	5 25
	$11 25

This sum paid for hoisting 45 tons in 10 hours, is equal to 25 cents per ton. In one case, where the hoist was 55 feet, the cost was 16 cents per ton.

In another case, with the ordinary two-bucket horse-whim, the cost of hoisting 65 feet, and landing, was 6 cents per ton; this did not include filling the buckets. In another case the ore was hoisted 40 feet, and landed for 5 cents per ton, not including the filling. Estimating the filling at 10 cents, these facts show that it costs in the cases cited an average of 1 cent to lift one ton of ore 7 feet, including the landing or dumping, which employs one man.

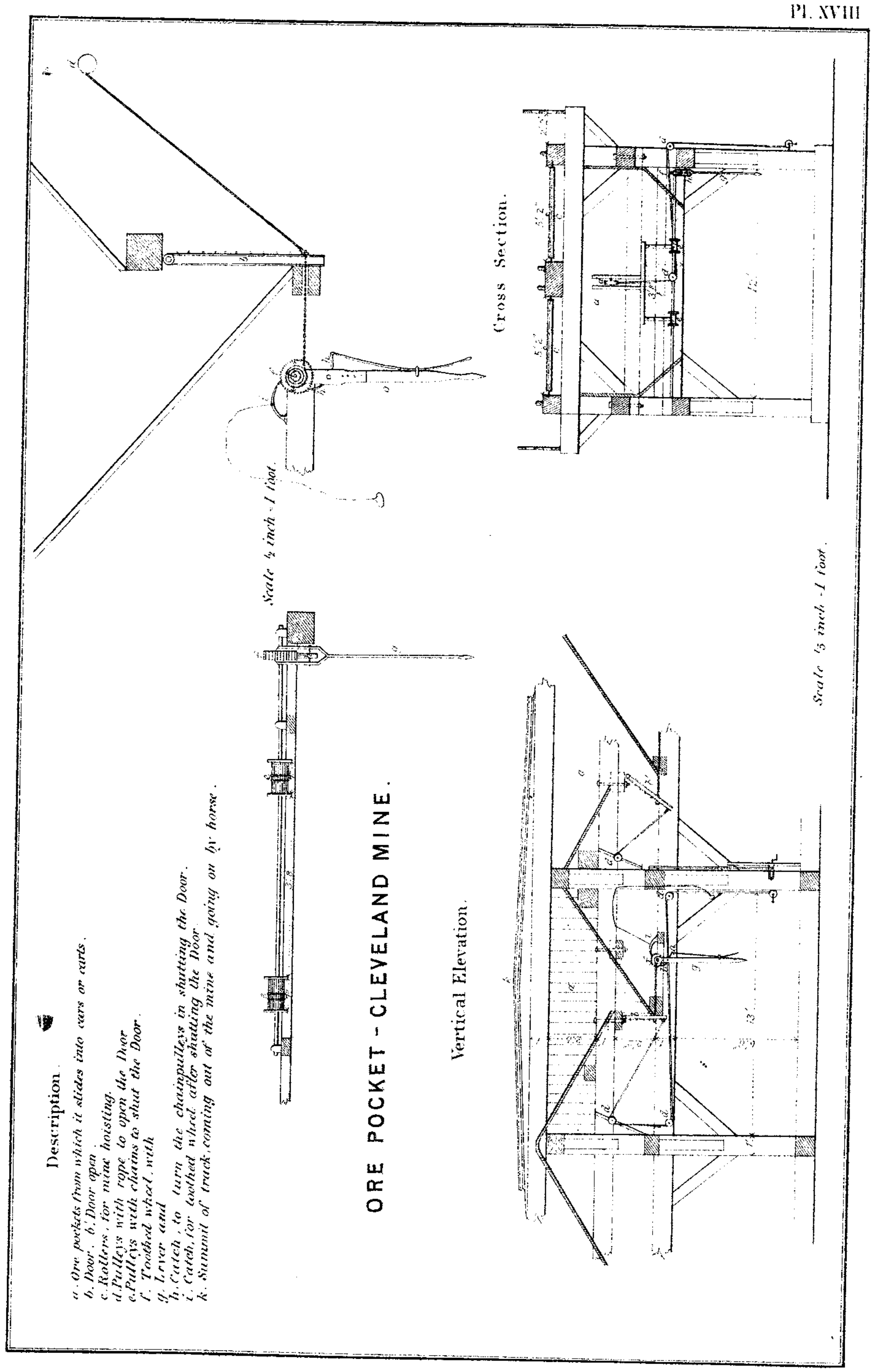
Without attempting to fully solve the important problem of the best mode of handling the material at Marquette mines, for that is beyond the scope of this report, I would suggest the following general policy as being safe for the mines to pursue :—

Let all large pits now worked, where a considerable amount of horse labor is required, be suspended until some form of steam machinery can be brought to bear on them. There are, of course, exceptions to this rule : for instance, where the other costs are unusually light, more money may be expended in handling the ore, as is often the case with the soft hematites ; but the principle is, I think, correct. It would not be difficult to find many instances of this kind ; for example, a given pit is worked, the ore being moved by horses, at a profit say of 50 cents per ton, which if left for one year could be reached by some tunnel or other improvement which would permit the same ore to be taken out at a profit of $1.00 per ton ; it would certainly pay to wait in such instances. In these cases it will usually be found that the superintendent has been persuaded into promising that his mine can be made to produce a certain amount of ore which may have been already sold, his attention being thereby fixed on a large product, rather than cheap mining. This subject will be considered more fully below. I will here only ask, if it is not better policy for a mine to net say $50,000 on 50,000 tons of ore, than to make the same sum on 100,000 tons. If the mines were inexhaustible it might not make much difference, but as it is, it may make all the difference there is between a profitable business and an unprofitable one in the end. It must be borne in mind, that while the ore business has been on the whole profitable, there are large mines that have been producing ore for years that have never returned a dollar to their stockholders.

Among the mining appliances which have been brought to great perfection in the Marquette region, are the various forms of pockets and shoots for transferring the ore, first, from the mine cars, buckets, and carts to the railroad cars, and second, from these to the vessel.

The magnificent ore docks at Marquette, Escanaba, and L'Anse belong to the latter class, and are undoubtedly the best of the kind

Pl. XVIII



in the United States if not in the world. They are described and illustrated in Chapter I., and in Appendix F. of Vol. II.

Of the first class there are numerous varieties, from the simple log crib built up alongside and above the track, into which the ore is dumped from elevated railways, and from the sloping bottom of which it is "shot" through holes closed by rods into cars at a cost of not over 3½ cents per ton, to the more expensive and perfect contrivance employed at the Cleveland mine, which is shown in Plate XVIII.

The mine car in this case passes over the centre of the pocket, which dumps its ore in turn into a car or cart below, by an ingeniously arranged door which is shown on an enlarged scale.

4. **Loading Ore from Stock Pile.**—During the winter no shipments are made from the mines, hence the product has to be piled up. It is the policy of some mines, and I think it is the best, to do most of their dead work in the winter, hence to stock but little ore; others maintain nearly the same rate of production in proportion to the force employed, winter and summer. Stocked ore has to be loaded in cars by hand, which is always contract work and costs from 9 to 12 cents per ton, the mean being, say 11 cents, including all costs connected with it. This amount, distributed over the whole product for the year, was found to average for the cases inquired into, $3\frac{5}{10}$ cents per ton.

5. **Machinery for Pumping and Hoisting.**—Notwithstanding the great cost of the work of horses, a large amount of machinery, as has already been remarked, is now in use, as the following statements will prove:—

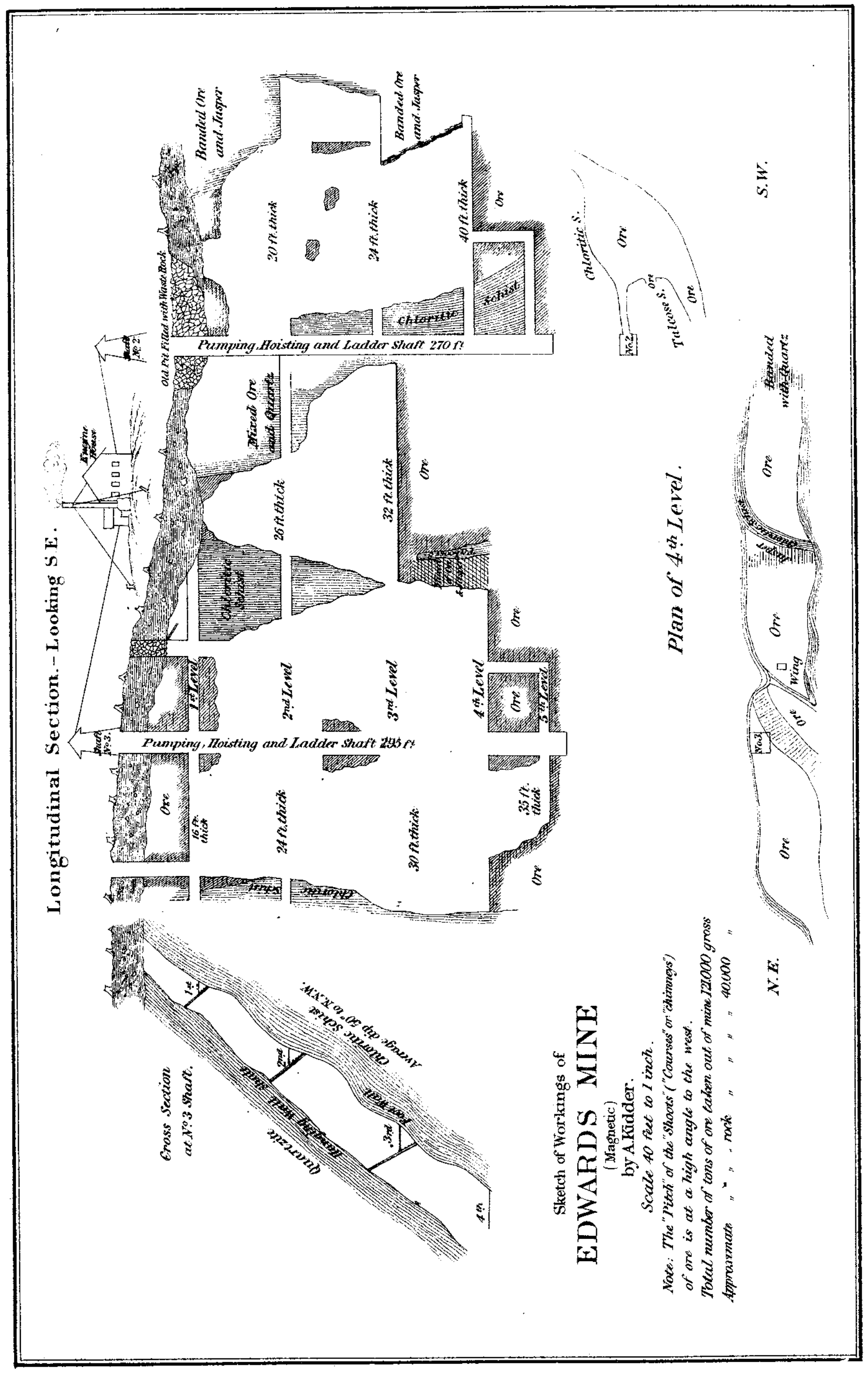
The introduction of machinery has so far seemed to make but little relative diminution in the number of horses employed, because of the greater amount of waste material which has to be moved in the later years. The amount given in the table, opposite this item, $11\frac{2}{10}$ cents, is designed to be an approximation to the cost of running the machinery of such mines as have plants distributed over the entire product of those mines. I estimate that less than one-half of the product of such mines was handled by machinery in 1870. The actual cost of moving the ore so handled, including the *pumping*, varied from 14 to 21 cents, the mean, as shown by my data, being about 18 cents. This cost is made up of wages of engineers and firemen, say fifteen per cent.; fillers, landers, and surface tramming, sixty per cent.; fuel, repairs of machinery and supplies, say twenty-five per cent. This covers the cost from miners' hands to cars or stock pile.

While this sum is materially less than the cost of the same work by horses, it is much greater than in the Copper region of Lake Superior, where this work is brought to great perfection. Some of the appliances employed in the Copper region cannot be used at iron mines on account of the greater irregularity of the deposits. But time will introduce many economies which will reduce this item below the figures given. It must be borne in mind, in comparing the cost of steam machinery with horses, that in the case of the engines all the pumping is included, while the horses handle only the ore and rock. Making this correction, it is safe to say that it costs at least four times as much to handle the same material by horses as by machinery.

The following description of recently erected plants will give a good idea of the machinery now in use at the iron mines, it being essentially such as is employed at the copper mines.

The *Macomber mine machinery* consists of one steam-engine with cylinder 18 × 24 inches, with bed cast solid in one piece. Valve is of the kind known as the H valve, and is worked by link motion; steam pipe 4 inches in diameter; exhaust pipe 6 inches in diameter; engine supplied with the Judson governor. Pump for feeding boiler is worked from cross-head; also an auxiliary for fire protection, etc. Main shaft is 5 inches in diameter, of hammered iron, and 16 feet long. One boiler 48 inch shell, 26 feet long, with two 18-inch flues. Smoke-stack is 40 feet high and 24 inches in diameter. The winding drums are 4 feet in diameter, and of sufficient capacity to contain 525 feet of 1¼ inch wire rope. They are worked by a friction movement, thrown in and out of gear by means of eccentrics with lever attachments. The brakes are known as band-brakes, which clamp the entire surface of the drum, 5 inches in width, and are of sufficient power to hold a loaded skip at any point in case of accident. They are worked by levers with hand or foot, as may be desired. The drums make about 13½ revolutions per minute, the engine making 80, which gives the skip a speed of a trifle less than 3 feet per second. The skips are of heavy boiler iron, each having four 12-inch wheels. The capacity of each is 35 cubic feet, equal to about 2½ tons of ore. The pump is 10 inches in diameter by 6 feet stroke, capable of discharging 660 gallons of

Pl. XIX.



water per minute. It is worked from a slotted crank arm, on end of main drum shaft, which admits of lengthening or shortening the stroke at pleasure. The pump is double acting, with single valve on a new plan. It is furnished with rods, travellers, connections, balance bobs, etc. This machinery was furnished complete in all its parts, and set up at the mine in working order for pumping and hoisting by the Iron Bay Foundry, Marquette, Mich., 1872.

The *Barnum mine plant* consists of one horizontal high pressure steam-engine of 20 inches diameter of cylinder and 30 inches stroke; steam furnished by two tubular boilers, each 48 inches in diameter and 14 feet long, and each containing 50 tubes, three inches in diameter. Maximum power of this engine is 120 horse, but is working at present at one-third its capacity. There are two winding drums, each 5 feet in diameter; speed of engine about 60 revolutions per minute, and of drums about 12. Drums are attached to main shaft by cone-gears, which are operated by steam cylinders and levers; screw-levers control the brakes and drums during the descent of the skip.

Engine is connected to the drum-shaft by spur-gearing in the proportion of one to five; speed of skip in shaft, about 3 feet per second; load of ore, 5,000 pounds; weight of skip, which is self-dumping, is 2,400 pounds, making the total load 7,400 pounds. Actual power employed, about 47 horse; engine also draws water with a 6-inch Cornish pump. Total weight of this machinery about 42 tons, and total cost about $10,000. Built at the Michigan Iron Foundry, Detroit, in 1869.

The foregoing described plants, together with those given in the subjoined tabular statement (pages 280 and 281), embrace over three-fourths of all the machinery employed in hoisting and pumping in the entire region.

V. Management and General Expenses.

This covers only such expenses as are incurred in the mining region, and not salaries of officers above the superintendent, nor the cost of selling the ore.

1, 2.—**Salaries, Office Expenses, and Taxes.**—This element of cost constitutes less than 5 per cent. of the whole cost of the ore,

DESCRIPTION OF STATIONARY ENGINES, WITH THEIR WORK, AT SIX MARQUETTE MINES, JANUARY, 1873.

Name of Mine.	Number or name of Pit or Shaft.	Size of Cylinder, Length and Diameter.	No. of Cylinders.	Number, size, and kind of Boiler.	Average working-pressure.	Nominal horse-power.	Kind of work, as pumping, hoisting, etc.	Height to which ore is lifted in feet.	Average number of tons hoisted in 24 hours.	Kind of Skip and its load.	Diameter of Barrel-pump in inches.	Kind of Pumps.	Revolutions of Engines per minute.	Hours per day that Pump is worked.	Shaft. Vertical.	Shaft. Inclined.	Kind and quantity of fuel used in 24 hours.	Remarks.
Jackson	Pit No. 4.	13″x 30″, one 40 horse, Root's pat'nt trunk engine	2	Steam supplied for this double and single engine from two of Root's patent boilers, 50 horse-power each, connected together.	70 lbs.	140	Hoisting.	125 feet.	120	Two 5 ft. drums, with 4 wheel, self-dumping. Skip-car 2½ tons.			75			2	One cord of wood per day; don't run at night.	There are also two (2) 12-horse power locomotives, which are used for distributing cars in the tunnels during the shipping season.
	Pit No. 6.	13″x 30″, one 40 horse Root's pat'nt trunk engine	1	do. do. do.	70 lbs.	40	Hoisting and pumping.	From 80 ft. to 125 ft.	200	Two 3 ft. drums, one hoisting skip-car 2½ tons, 4 hoisting patent dump buckets 1 ton each.	8	Cornish jack-head.	100	10	1	1		
	Pit No. 7.	8″x 12″	2	One boiler, 42″ diameter x 12 feet long, tubular, 40-3 in. flues.	70 lbs.	20	Hoisting and pumping.	50 feet.	50	Inside dump-car 3 tons.	8	Cornish jack-head.	100	12		1	One cord of wood per day; don't run at night.	Also four (4) steam pumps, which are used in various parts of the mine, viz.: 1 No. 9 Earle steam pump; 1 No. 8 Knowles steam pump; 1 No. G Cameron steam pump; 1 Worthington duplex pump; also one 8 (eight) inch double-acting bucket pump.
	Pit No. 5.	5″ x 8″	2	Tubular boiler, 40 in. diam. x 13 ft. long, 40-3 in. tubes.	70 lbs.	8	Hoisting.	50 feet.	40 tons of ore, rock and water.	Bucket 1 ton.			100	10	1		¾ cord per day.	
	Machine shop.	8 x 16 inches.	1	Tubular boiler, 60 in. diam. x 25 ft. long, 121-2 in. tubes.			Running machinery in shop.						80				One cord per day.	
Champion	4 shafts now worked by main engine. 2 new shafts now being sunk.	One horizontal engine, 14 inches bore, 20 in. stroke of piston.	1	Two return flue boilers, 42 inches diam., 28 ft. long, 2 flues in each, 16 inches diameter. One locomotive boiler, 28 inches diam. of shell, 26 x 30 in. fire-box, 36-2 in. flues, at 1st level of No. 3 shaft.	65 lbs. to the sq. in.	60 on hoisting drums	One 6-inch plunge pump. One No. 7 Earle pump, at 3d level of No. 3 shaft; elevating water to surface; supplied with steam from boiler at 1st level.	180 feet.	400 from 4 shafts.	Wrought-iron skips, 42 inches long, 30 in width and depth. Hold 3,000 lbs. of ore.	6	Plunge-pump, 6 in. diameter of cylinder and 6 in. column, elevating the water to the surface 180 feet.	20	22		incl'd	Mixed wood, four cords in 24 hours.	Makers—Hodge & Christie, Detroit, Mich. This one engine does all the work of this mine.
Edwards.	Nos. 2 & 3.	24 x 36 inches.	1	Two. 5 ft. diam., 27 ft. long, with return flues each.	70 lbs.	150	Pumping and hoisting.	300 feet.	200	Cornish skip 1½ tons.	Two 6 in. One 7 in. One 8 in.	Two 6-in. draw-lifts from 5th to 4th levels, at Nos. 2 and 3 shafts. One 8-in. draw-lift, at No. 2 shaft, from 5th level to 2d. One 7-inch plunger-pole, from 4th level at No. 3 shaft, taking also No. 2 water to surface.	30	20		incl'd	Wood, six cords.	Makers—Hodge & Christie, Detroit. See plan of mine—Plate XIX.
Lake Angeline.......	2 Pits.	16 x 24 inches.	1	One. 42 in. shell, 20 ft. long, with 2-14 in. flues.	60 lbs.	60	Pumping and hoisting.	75 feet.	150	Cornish skip 1½ tons.		One 10-inch double-acting pump.	30	10		incl'd	Wood, 2½ cords. Coal, ¾ ton.	Maker—D. H. Merritt, Marquette.
Washington.	At No. 7 opening, known as No. 1 & 2, skip roads.	16 x 24 inches.	1	One boiler, 2 flues, 24 ft. 6 in. length, 44 in. diameter.	90 lbs.	50	Hoisting.	No. 1 skip, 130 feet. No. 2 skip, 55 feet.	44 / 35	Iron self-dumper about 1 ton.		Earle. Nos. 4, 6, and 7.	see catalogue.	3	vert'l		Coal, hard & soft wood; about 1,500 lbs. coal in 24 h.; 4 cords wood in do.	Furnishing steam for Burleigh Drill Compressor, 3 Earle pumps (2 No. 4 & 1 No. 7), besides to hoisting engi's.
Lake Superior ..	Main shaft.	20 x 30 inches.	1	Two boilers, 3 flues, 43 x 6 feet.	60 lbs.		Hoisting and pumping.	160 feet.	350	Iron skip 3 tons.	10	Plunger.	about 30	10		incl'd	Six cords wood.	Makers—Wash'n Iron Works, N'burgh, N. Y.
	Hematite.	12 x 20 inches.	1	One boiler, 2 flues, 3½ x 24 feet.	65 lbs.		Hoisting and pumping.	130 feet.	100	Iron car 3 tons.	8	Bucket plunger.	about 60	14		incl'd	Three cords wood.	
	Portable engine & boiler—"Sect. 16."	10 x 18 inches.	1	One boiler, flue.	30 lbs.		Hoisting and pumping.	60 feet.		Iron skip 2 tons,	6	Bucket plunger.	about 40	10		incl'd	Three cords wood.	
	Sect. 21.	10 x 12 inches.	1	One boiler, upright flue.	35 lbs.		Hoisting.	60 feet.		Iron skip 2 tons.			about 80			incl'd	Three cords wood.	

amounting to about 12 cents per ton. I am happy to note here a much better showing than in the Persberg mines, Sweden, where this item, in 1870, cost 16½ per cent. of the whole, or 36 cents per ton of ore; nearly three times its cost with us. I presume the excess of this item in Sweden may be largely due to heavier taxes, and smaller production.

CHAPTER X.

CHEMICAL COMPOSITION OF ORES.—ANALYSES.

THIS chapter contains the results of over one hundred and fifty analyses, more or less complete, of iron ores from the Upper Peninsula of Michigan, mostly from the Marquette region, together with five analyses of pig-iron produced from these ores; and several analyses of ores from other parts of the U. S., which are largely used with Lake Superior ores as mixtures. In order to bring out the variations in quality of the ores, and to obtain *reliable practical averages*, seldom less than two and in one instance eight samples were analyzed from the same mine.

By far the largest portion of the samples, the analyses of which appear in this Report, were selected by myself with a view to obtaining a fair and *safe average* of the ore sampled, one that would be borne out and confirmed by practically working the same ore in the furnace. I am well aware, from extended observation and practical experience, that a large majority of the published analyses of iron ores, not only have no practical value, but are positively detrimental to the best interests of the iron trade, representing as they so often do the ores to be richer in iron than they actually are, simply because the samples analyzed were not honestly or skilfully collected. Even the most skilful and conscientious men, if they err at all in collecting a sample from a new iron location, are almost sure to err on the side of finding too much, rather than too little iron. The chemist is often wrongly blamed for these false results. My experience with many analysts leads me to believe that they are, as a rule, thoroughly honest and painstaking men, who return correct results for the *samples sent them;* the trouble is with the samplers. This point receives further consideration under Explorations, Chapter VII.

In earnestly endeavoring to avoid this rock on which so many mining engineers and geologists have wrecked their reputations, I may in some instances have gone to the opposite extreme and collected samples which were below the average richness—at least I am quite persuaded that I shall be charged with this—hence venture this explanation in advance of the charge. If such mistakes are found, I can only say myself and not the analysts are to blame, and I stand ready to make such corrections as lie in my power.

My *method of sampling* is as follows:—1st. To obtain an average of a producing mine; I found that the immense stock piles accumulated at Cleveland, Ohio, at the end of the shipping season, afforded excellent opportunities for sampling. The stock piles at the mines or a large number of loaded cars were often resorted to, and in many instances it was thought best to go into the mine and take the samples from the solid ledge or the loose ore as it was being taken out. In either case an ordinary shot bag, holding 4 *or* 5 *pounds of ore, was filled with small fragments, varying from the size of a pea to that of a walnut, of all kinds of ore, from all parts of the pile, together with the rock, if any, which was found mixed with the ore.* Some of these fragments were picked up and some were broken from larger pieces; the dust and mud over the ore made it often impossible to distinguish whether the pieces taken were ore or rock. These samples were all pulverized and thoroughly mixed, and from this the specimens were taken for the chemist, the same being forwarded by mail in small numbered tin tubes; and in each instance a pound or more of the pulverized ore was retained for future reference. The reserved portions are now in my safe in Marquette, from which samples will be furnished to any who may desire. 2d. To obtain an average sample from a new locality or from exploration pits is more difficult and unsatisfactory. This subject is fully treated under Explorations, Chapter VII.

With all this care my results varied, in extreme cases, from 10 per cent. below to 5 per cent. above the true average, but the common variation was not more than three per cent. Two or three of the extreme results, known to be wrong, are omitted from the tables. The name of the sampler is in every case given when known, and the circumstances of its collection are briefly stated in the notes. The samples collected by E. R. Taylor, of Cleveland, were, at my request, taken in accordance with the rules above given.

The surname of the chemists and date at which analysis was

made, as near as could be ascertained, are given under the result in every instance except one. The number of analyses made, with names in full and address of these gentlemen, are as follows:—

	No. Made.
Professor Oscar D. Allen, New Haven, Conn....	17
Professor Geo. J. Brush, New Haven, Conn.....	1
J. Blodgett Britton, Philadelphia, Pa...........	56
A. A. Blair, St. Louis, Mo....................	2
Dr. C. F. Chandler, School of Mines, N. Y......	8
Dr. C. F. Chandler and F. A. Cairns, School of Mines, N. Y..........................	12
Chandler and Schweitzer......................	1
F. H. Emmerton, Chicago, Ill..................	1
F. B. Jenney, Marquette, Mich.................	8
Prof. Geo. W. Maynard, New York............	5
Maynard and Wendel.........................	3
Ed. R. Taylor, Cleveland, Ohio...............	14
Dr. A. Wendel, Troy, N. Y...................	20
Dr. Otto Wuth, Pittsburgh, Pa................	30
Samuel Peters...............................	1
T. G. Wormley..............................	4

The metallic iron was usually determined by but one chemist, as the chances of difference on this element are small. Phosphorus determinations are more difficult, and considerable differences in the amount of this element found in the same sample by different chemists, will be observed. For this reason duplicates were often sent to two and sometimes to three; the results being given as returned by them. If any one supposes the differences to be due to errors in samples, which is improbable, I will gladly furnish duplicates for re-examination. The specific gravities of powder were mostly determined by Mr. Jenney, and not by the chemists over whose names they are sometimes placed.

The subjoined table contains an approximate general summary of the results, exhibiting the average composition of the four classes of ore now produced by the following mines:—

I. *Red Specular Ores.* Barnum, Cleveland, Jackson, Lake Superior, New York, Republic, and Kloman.

II. *Black Magnetic and Slate Ores.* Champion, Edwards, Michigan, Spurr, and Washington.

III. *Soft Hematites.* Foster, Lake Superior, Lake Angeline, Taylor, Macomber, New England, Shenango, S. C. Smith, and Winthrop.

IV. *Flag Ore.* Cascade.

Table No. XIII. of Atlas contains a somewhat similar summary so far as metallic iron and phosphorus are concerned. More facts are incorporated in this table, which has slightly changed the averages.

	I.	II.	III.	IV.
Protoxide of Iron		19.639		
Sesqui- or Peroxide of Iron	90.52	67.761	75.75	70.98
Oxide of Manganese	Trace.	0.13	0.80	Trace.
Alumina	1.39	2.13	1.536	2.01
Lime	0.70	0.68	0.36	0.45
Magnesia	0.42	0.69	0.294	0.20
Sulphur	0.05	0.132	0.110	0.03
Phosphoric Acid	0.258	0.199	0.185	0.13
Silicic Acid, Silica, or Insoluble Silicious Matter	5.892	7.828	14.035	25.12
Water, Combined			3.94	
" Uncombined			1.18	
" Total	0.77	0.811		1.08
Volatile Matter			1.81	
	100.000	100.000	100.000	100.00
Metallic Iron	62.915	62.930	52.649	49.332
Phosphorus	0.111	0.085	0.078	0.053
Sulphur	0.05	0.132	0.110	0.03
Metallic Manganese	Trace.	0.091	0.56	Trace.
Specific Gravity	4.74	4.59	3.88	4.09

A glance at this table shows us that, except the soft hematite III., which contains about 5 per cent. of water, all the ores are essentially and chiefly composed of oxide of iron and silica or insoluble silicious matter. The other elements, viz., oxide of manganese, alumina, lime, magnesia, sulphur, phosphoric acid, and water amount in the aggregate to only about 5 per cent. in the I., II., and IV. classes. So constant is this ratio that a valuable determination of iron in a hard ore, and one sufficiently accurate for practical purposes, can be made by ascertaining the percentage of insoluble silicious matter, adding 5 to it and subtracting the sum from 100. The result is the iron oxide, which, multiplied by .70 for red, and .72 for black oxides, gives the metallic iron.

Regarding the percentage of metallic iron, consumers of Lake

Superior ores will at once note that their furnace books very often show a higher yield than 62.9 per cent., which is given in the table as the average percentage for first-class ores. This may not have been the case in exceptional years, like 1872, when the consumption so crowded the production that mines had not the time nor skilled labor to make such selection as they usually make. But that furnaces running on first-class ores usually make a better yield than that given, is shown by "Table of Metallurgical Qualities of certain Lake Superior Ores by Consumers," Plate No. XIII. of Atlas, where various consumers credited these ores, in 1870, with an average of *over sixty-four per cent. of iron*, as shown by their furnace-books. This discrepancy is easily accounted for; the chemist's result is in *pure metallic iron*, the furnace man's is in *pig iron*, which contains several per cent. of carbon and silicon, and other substances,—see subjoined analyses. Therefore the chemist should always find *less* iron than is shown by the furnace accounts if he has an *average* sample of the ore. Just what this difference is depends on the grade of iron made, on the waste in the slag, and other things: good authorities have placed it at 2½ per cent.

Passing to a more detailed examination of the facts recorded in the table, we find, in descending order,—oxide of *manganese* has a maximum of nearly one per cent. in the hematite, and is nothing in the specular and flag ores. If the hematite was subdivided into manganiferous and non-manganiferous varieties, as suggested under Lithology, Chapter III., then one variety would contain only a minute quantity of manganese, while the other would reach an average of, say 3 per cent. of the oxide. The presence of manganese adds to the value of an ore, especially for making steel. *Alumina* reaches a maximum of over 2 per cent. in the magnetite ores, and is least in the specular ores. The earthy character of the hematites would lead one to expect more of this element in that class. *Lime* and *magnesia* aggregate a trifle over one per cent. in the high grade ore, and less than this amount in those of low grade. *Sulphur* is relatively most abundant in the magnetites; but, so far as I know, the minute quantity found has never been objected to by consumers of the ore. The quantity of *phosphoric acid* and phosphorus is of such moment in connection with the wants of the Bessemer steel manufacture, now rapidly developing in the West, that this subject will receive especial attention hereafter.

The distribution and relations of the *silicious matter* have been mentioned ;—it has its maximum in the flag ores where it reaches one-fourth of the whole weight, and is least in the rich speculars, which contain only about 6 per cent. on the average.

The total *water* in the hard ores is only about 1 per cent. In the soft hematites it rises to an average of over 5 per cent., and, as will be seen in the subjoined analyses, increases in a few instances to about twice this amount, the greater part of which is combined with the limonite, which largely makes up the soft ore. An appreciable amount of *volatile* matter, supposed to be mostly carbonaceous, occurs only in the hematite ores. The specific gravities given will be observed to have a very significant relation to the amount of iron, which subject is considered fully in Chapter III.

Phosphorus in Lake Superior Ores.

Pig-iron intended for the use of *steel* makers must be remarkably free from phosphorus, *one-tenth of one per cent.*, according to some authorities, being the maximum amount allowable for many purposes. As it has been found impossible, up to this time, to eliminate this element from the metal either in the blast furnace or in any of the various processes for making steel, it is indispensable, in steel manufacture, that we start with an ore comparatively free from it; and for the best bar iron, only a very small amount of phosphorus is admissible,—its effect being to produce cold shortness.

It is a safe practical maxim of iron metallurgy that all the phosphorus contained in the coal, limestone, and ore charged into a blast furnace will be found in the resulting pig-iron, and that the conversion of such pig-iron into steel will increase the phosphorus just in the ratio in which the metal is wasted in the process. It is therefore very evident, if say one-tenth of one per cent. only is admissible in steel, not only our ores but fuel and flux must be very free from phosphorus at the start. In considering the facts regarding this element here given, it must be constantly borne in mind that a rich ore may contain more phosphorus than a lean ore, and yet produce a pig-iron containing less phosphorus than the other, because *less of the rich ore is required* to make a ton of iron.

To illustrate: an ore yielding $66\frac{2}{3}$ per cent. in the furnace, and containing .06 of phosphorus, will produce a pig containing .09 of phosphorus; while an ore containing but 50 per cent. of iron and .05 of phosphorus will produce a pig containing .10 of phosphorus; therefore the amount of iron in the ore must be always considered in comparing the amounts of phosphorus. Applying this rule to the facts given in the foregoing table, we shall find that the apparent greater freedom of the hematite and flag ores from phosphorus is nearly balanced by their comparative poverty in iron.

The distribution of phosphorus among the Lake Superior ores, so far as my facts go, follows no obvious law; it seems to have little, if any, relation to the kind of ore. Some of the hematite ores are among the lowest and others among the richest in this element, and so of the specular and magnetic ores.

A rule, to which there are, however, several exceptions, seems to be that the ores poor in iron and rich in silica, contain least phosphorus; but the analyses of the Republic mountain ore show more iron and less silica than in any other, and that it is also very low in phosphorus. The table of analyses, in Plate No. XIII. of Atlas, presents most of the facts in a compact form; but as this subject is of peculiar interest at this time in connection with the Bessemer steel manufacture, I venture to incorporate a second tabular statement here, in which the mines are arranged in order of the quantity of phosphorus, beginning with the lowest. No mine is included from which less than two samples have been analyzed. The deposits and mines marked with a * are new, and not sufficiently developed to enable me to say that an average sample of the ore was obtained.

Mine.	Kind of Ore.	Phosphorus.	Iron.
Lake Angeline......	Jaspery Specular.....	0.031	53.83
Winthrop...........	Soft Hematite........	0.037	54.63
Republic*..........	Specular and Magnetic	0.040	66.51
Michigamme*........	Magnetic............	0.041	64.388
Silas C. Smith......	Hematite............	0.047	49.70
Cascade............	Flag................	0.053	49.332
Menominee Iron reg'n*	Specular & Hematite.	0.054	48.209
Edwards............	2d Class Magnetic....	0.055	49.190
Macomber..........	Hematite............	0.058	54.92
Cascade............	Flag and Specular....	0.061	51.253

Mine.	Kind of Ore.	Phosphorus.	Iron.
Jackson	Specular	0.066	63.715
Magnetic*	Magnetic	0.067	54.72
Edwards	Do.	0.067	61.60
Shenango	Hematite	0 070	56.315
Champion	Magnetic and Slate	0.072	63.55
Negaunee*	Manganifs. Soft Hem'e	0.074	44.29
Lake Angeline	Hematite	0.079	50.70
New England	Soft Hematite	0.080	48.24
Kloman*	Specular	0.089	63.55
Foster	Hematite	0.094	52.27
Spurr Mountain*	Magnetic	0.104	63.81
Lake Superior	Specular	0.104	62.11
Taylor (L'Anse)*	Hematite	0.107	52.88
Jackson	Hematite and Jaspery.	0.124	57.155
Cleveland	Specular	0.126	61.092
Lake Superior	Hematite	0.130	54.19
Saginaw*	Specular and Hematite	0.132	52.40
Barnum	Specular	0.134	61.69
Washington	Magnetic	0.141	61.305
New York	Specular	0.224	61.74

It has been stated that an inspection of the first table did not warrant us in asserting that either of the four classes of ore represented could be easily recognized as being comparatively free from phosphorus; so an examination of the above presentation of the facts forces us to the conclusion that the distribution is not geographical; for we here see widely-separated mines containing the same amount of phosphorus, whilst contiguous mines vary widely. In fact, in different parts of the same mine there is found a wide difference in the quantity of this noxious element; *e. g.:* The New York mine results show more than twice as much phosphorus in the ore from pit No. 1 as from pit No. 2; and the Lake Superior ore appears to contain less phosphorus than the Barnum, although they belong to one deposit. A part of this difference is undoubtedly due to errors in sampling and errors in the analysis; but the number of samples analyzed, the care taken in collecting them, and the reputation of the chemists, leave but little doubt that the relative and absolute average amounts of phosphorus in the

ores from the developed mines are nearly expressed in the foregoing table.

At the suggestion of Mr. A. L. Holley, I selected, with much care, an average sample of the rock which occurs in the hard ores, more or less of which goes into the furnace, and had it analyzed; the result was less than the average amount of phosphorus. This fact, in connection with the low amount found in the second class and flag ores, leads me to believe that no care in selecting and sorting ore will diminish the quantity of phosphorus.

By way of verifying the amount of phosphorus in Lake Superior ores, here given, there are presented in the following table five analyses of pig-iron made from them with charcoal, and a flux containing no appreciable amount of phosphorus. They may, therefore, be said to indicate very accurately the amount of phosphorus in the ores, which, as will be seen, averages about the maximum amount given above as admissible in steel.

	1	2	3	4	5	Average.
Magnesia			0.47			
Silicic Acid, or Silica		1.16	1.83	3.21	2.91	2.28
Silicon	2.245					
Graphitic Carbon	2.88	3.72	3.35		3.61	3.39
Combined "	.80	0.30	0.00		.05	.38
Metallic Iron	93.201		93.49			93.34
Phosphorus	.138	0.104	0.082	0.126	.092	0.108
Sulphur	.011	0.045	trace.		.04	0.032
Metallic Manganese	.174					.174

No. 1 was chipped from many pigs of No. 1 gray foundry iron made at the Pioneer furnace Negaunee, of Jackson ore. Analysis by Dr. C. F. Chandler. No. 2 is a pig-iron made from assorted Lake Superior ores at the Appleton Furnace, Wisconsin. Analysis by Mr. Morrell. No. 3 is also a specimen of Appleton iron. Analysis by Dr. Wuth. No. 4 is No. 1 gray foundry iron made by the Jackson Iron Co. at Fayette, Michigan, of Jackson ore with charcoal, and is extensively used in the manufacture of Bessemer steel. Analysis by Mr. Morrell. No. 5 is a specimen of pig made by the Michigan Iron Co. in Marquette County, of a mixture of specular, magnetic, and hematite ores. Analysis by Mr. Morrell. The analysis of Pioneer pig was at the expense of the Survey; the others were furnished by Mr. Holley. It was proposed to carry this work much further, but the limited means would not permit.

For contributions in money, and valuable suggestions and encouragement in obtaining the results set forth in this chapter, I am under especial obligation to John Fritz, of Bethlehem, Pa., and S. P. Ely, of Marquette; A. Pardee, Daniel J. Morrell, A. B. Meeker, and W. H. Barnum also contributed liberally towards paying for the chemical work, which cost nearly $2,000.

The physical and mineralogical character of the following ores is given under Lithology, in Chapter III. For commercial statistics, and, incompletely, the metallurgical qualities, see Plates XII. and XIII. of Atlas.

(The mines are arranged alphabetically. The upper line gives the number of the sample.)

BARNUM MINE—*Specular Ore.*

	58.	14.*	14.*	262.*	262.*	277.*	277.*	*Averages.*
Sesqui- or Peroxide of Iron	93.40	86.71						
Oxide of Manganese	......	trace						
Alumina	0.33	1.92						
Lime	0.30	0.64						
Magnesia	0.15	0.53						
Sulphur	min'te trace.	0.04						
Phosphoric Acid	0.23	0.25	0.189	0.31	0.288	......	0.649	
Silicic Acid, or Silica	4.80	9.43						
Water, Total	0.29	0.46						
	99.50	99.98						
Metallic Iron	65.38	60.79	......	64.30	......	56.31	......	61.69
Phosphorus	0.10	0.11	0.083	.133	0.123	0.149	0.278	.134
Sulphur	......	0.04						
Specific Gravity	......	4.58						
	Chemist, Allen. Sept. 2, 1871. *Sampler*, Brooks.	*Chemists*, Chandler & Cairns. Mar. 4, 1872. *Sampler*, Brooks.	*Chemist*, Wuth. *Sampler*,	*Chemist*, Taylor. *Sampler*, Taylor.	*Chemist*, Wendel. *Sampler*,	*Chemist*, Britton. Dec. 31, 1872. *Sampler*, Brooks.	*Chemist*, Wendel. Feb. 6, 1873. *Sampler*,	

NOTES.—58. From three stock piles at mine. 14. Large stock pile at Cleveland. 262. Stock pile at Cleveland. 277. All parts of mine.

CLEVELAND MINE—*Specular Ore.*

	36.	36.	36.	260.	260.	271.	271.	272.	272.	273.	*Averages.*
Sesqui- or Peroxide of Iron	88.50										
Oxide of Manganese	trace.										
Alumina	1.84										
Lime	0.89										
Magnesia	0.75										
Sulphur	0.01										
Phosphoric Acid	0.46	0.229	......	0.178	0.14	0.343	......	0.218			
Silicic Acid, or Silica	6.40										
Water, Total	1.23										
	100.08										
Metallic Iron	61.95	......	......	......	62.10	......	56.590	......	......	63.730	61.092
Phosphorus	0.20	0.100	0.187	0.076	.061	0.147	0.168	0.093	0.154	0.111	0.119
Sulphur	0.01										
Metallic Manganese	trace.										
Specific Gravity	4.64	......	......	......	......	4.42	......	4.37	......	4.93	
	Chemists, Chandler & Cairns. Mar. 9, 1872. *Sampler*, Brooks.	*Chemist*, Wuth. *Sampler*,	*Chemist*, Britton. *Sampler*,	*Chemist*, Wendel. *Sampler*, Taylor.	*Chemist*, Taylor. *Sampler*,	*Chemist*, Wendel. Feb. 6, 1873. *Sampler*, Brooks.	*Chemist*, Britton. Dec. 31, 1872. *Sampler*,	*Chemist*, Wendel. Feb. 6, 1873. *Sampler*, Brooks.	*Chemist*, Britton. Dec. 31, 1872. *Sampler*,	*Chemist*, Britton. Dec. 31, 1872. *Sampler*,	

NOTES.—36. Large stock pile in Cleveland. 260. Stock pile in Cleveland. 271. Laurie Genth's Pit, No. 3. 272. Swede's pit. 273. School House opening. The last three were from mine.

* The occurrence of the same number more than once in this line, signifies that duplicates of the same sample were sent to different chemists.

CHAMPION MINE—*Magnetic and Slate Ore.*

	38.	38.	38.	227.	227.	228.	228.	*Averages.*
Protoxide of Iron	17.87							
Sesqui- or Peroxide of Iron	74.93							
Oxide of Manganese	0.05							
Alumina	1.15							
Lime	0.52							
Magnesia	0.92							
Sulphur	0.12							
Phosphoric Acid	0.28	0.116	......	0.021	0.337	0.161	0.316	
Silicic Acid, or Silica	3.70							
Water, Total	0.52							
	100.06							
Metallic Iron	66.04	......	......	......	57.97	......	66.65	63.55
Phosphorus	0.12	0.051	0.048	0.009	0.143	0.070	0.136	.084
Sulphur	0.12							
Metallic Manganese	0.03							
Specific Gravity	4.75	......	4.43	......	......	4.87		
	Chemists, Chandler & Cairns. Mar. 9, 1872. *Sampler,* Brooks.	*Chemist,* Wuth. *Sampler,*	*Chemist,* Britton. *Sampler,*	*Chemist,* Wuth. *Sampler,* Brooks.	*Chemist,* Wendel, Feb. 6, 1873. *Sampler,*	*Chemist,* Wuth. *Sampler,* Brooks.	*Chemist,* Wendel, Feb. 6, 1873. *Sampler,*	

NOTES.—38. Large stock pile in Cleveland, all varieties. 227. "Slate ore," Shaft No. 4. 228. "Black ore," Shafts Nos. 1, 2, and 3. The two last from mine.

CASCADE MINES—*Flag Ore.*

	17.	22.	22.	257.	257.	258.	258.	15.	*Averages.*
Sesqui- or Peroxide of Iron	71.98	83.70	......	......	......	......	......	66.20	
Protoxide of Manganese	0.01	trace.							
Alumina	0.68	3.34							
Lime	0.16	0.75							
Magnesia	0.06	0.34							
Sulphur	0.04	0.03							
Phosphoric Acid	0.07	0.24	0.248	......	......	......	......	.14	
Silicic Acid, or Silica	......	10.67							
Insoluble Silicious Matter	25.26	......	......	.....	......	......	......	31.02	
Water, Total	1.03	0.87	......	......	......	......	......	1.29	
Alkalies, undetermined and lost	0.71								
	100.00	99.94							
Metallic Iron	50.49	58.59	......	46.120	......	45.010	......	46.450	49.332
Phosphorus	0.03	0.10	0.108	.042	0.043	0.027	0.036	0.060	.053
Sulphur	0.04	0.03							
Specific Gravity	......	4.43	......	3.95	......	4.01			
	Chemist, Britton, Aug. 18, 1870. *Sampler,* Brooks.	*Chemists,* Chandler & Cairns, Mar. 4, 1872. *Sampler,* Brooks, J'y,'72	*Chemist,* Wuth, 1872. *Sampler,*	*Chemist,* Britton, 1872. *Sampler,* Brooks.	*Chemist,* Allen, 1872. *Sampler,*	*Chemist,* Britton. *Sampler,* Brooks.	*Chemist,* Allen. *Sampler,*	*Chemist,* Britton, Aug., 1870. *Sampler,* Brooks.	

NOTES.—17. Selected bird's-eye slate ore. Exploration pit. 22. The richest pieces from a small stock pile in Cleveland. 257. Emma mine. 258. Bagley mine; bird's-eye slate ore. The two last were obtained from the mine workings. 15. Old opening, north face ridge, S.W. corner. Sect. 29.

CASCADE MINES—*Flag and Specular Ore.*

	259.	259.	266.	266.	256.	256.	*Averages.*
Phosphoric Acid	......	......	0.16	0.096			
Metallic Iron	50.820	....	44.00	....	58.940	....	51.253
Phosphorus	0.078	0.073	0.069	0.041	0.055	0.055	0.061
Specific Gravity	4.13	....	....	....	4.44		
	Chemist, Britton. 1872. *Sampler,* Brooks.	*Chemist,* Allen. 1872. *Sampler,*	*Chemist,* Taylor. *Sampler,* Taylor.	*Chemist,* Wendel. *Sampler,*	*Chemist,* Britton. 1872. *Samplers,* J. Fritz & A. Pardee.	*Chemist,* Allen. 1872. *Sampler,*	

NOTES.—259. Saw-Mill opening, west of stream. 256. West End Mine (specular ore). Stock pile at Mine. 266. Stock pile at Cleveland.

CANADIAN ORES—*Magnetic.*

	222.	217.	216.	220, *b*.	220, *a*.	*Averages.*
Bisulphide of Iron	....	....	....	....	2.19	
Sesqui- or Peroxide of Iron	....	....	....	78.03		
Proto-sesquioxide of Iron	92.19	....	....	....	84.38	
Alumina	.68	....	....	1.17	2.86	
Lime	.28	....	....	....	0.74	
Magnesia	.83	....	....	....	5.61	
Sulphur	.78					
Phosphoric Acid	.14	0.21	....	0.077	0.087	
Silicic Acid, or Silica	3.55	....	....	6.10	4.13	
Water, Total (moisture)	.48					
Carbonate of Lime	....	....	....	13.71	....	
Carbonate of Magnesia	....	....	....	0.91	....	
Oxygen with the Sulphur and loss	1.07					
	100.00			99.997	99.997	
Metallic Iron	66.86	51.40	45.20	54.00	60.00	55.49
Phosphorus	.06	0.092	.037	.033	0.037	0.052
	Chemist, Britton. Nov. 17, 1870. *Sampler,* Brooks.	*Chemist,* E.R. Taylor. Jan. 2, 1873. *Sampler,* Taylor.	*Chemist,* Taylor. Jan. 2, 1873. *Sampler,* Taylor.	*Chemist,* Wuth. *Sampler,*	*Chemist,* Wuth. *Sampler,*	

NOTES.—222. Analysis furnished by Redington and Adams, Cleveland. 217. Stock pile at Cleveland. 216. Stock pile at Cleveland. 220. Analyses furnished by Dr. Wuth. *a*. Magnetic ore after roasting: *b*. Red hematite. 222 and 217 are Forsyth ore. 216 and 220 are Marmora ore.

EDWARDS MINE—*Magnetic Ore.*

	41.	41.	41.	199.	*Averages.*
Protoxide of Iron	21.60	....	....	9.98	
Sesqui- or Peroxide of Iron	55.80	....	....	85.41	
Oxide of Manganese	0.10				
Alumina	4.34				
Lime	0.77				
Magnesia	0.84				
Sulphur	0.16				
Sulphuric Acid	....	....	....	.03	
Phosphoric Acid	0.12	0.288	....	.07	
Silicic Acid, or Silica	15.41				
Insoluble Silicious Matter	....	....	....	2.43	
Water, Total	0.81				
	99.95				
Metallic Iron	55.75	....	....	67.45	61.60
Phosphorus	0.05	0.125	0.137	.030	.067
Sulphur	0.16				
Metallic Manganese	0.06				
Specific Gravity	4.24				
	Chemists, Chandler & Cairns. March 9, 1872. *Sampler*, Brooks.	*Chemist*, Wuth. *Sampler*,	*Chemist*, Britton. *Sampler*,	*Chemist*, Taylor. Jan., 1873. *Sampler*, Unknown.	

NOTE.—41. Large stock pile in Cleveland.

EDWARDS MINE—*Second-class Magnetic Ore.*

	265.	265.	286.	*Averages.*
Phosphoric Acid	0.10	0.136		
Metallic Iron	48.80	....	49.580	49.190
Phosphorus	0.043	0.058	0.061	.055
	Chemist, Taylor. *Sampler*, Taylor.	*Chemist*, Wendel. *Sampler*,	*Chemist*, Britton. Jan. 9, 1873. *Sampler*, Brooks.	

NOTES.—265. Stock pile at Cleveland. 286. From mine.

FOSTER MINE—*Hematite Ore.*

	49.	87.	270.	270.	26.	*Averages.*
Sesqui- or Peroxide of Iron	74.69	....	....	....	79.49	
Oxide of Manganese	.42	....	....	....	0.25	
Alumina	.50	....	....	....	1.19	
Lime	.37	....	....	....	0.27	
Magnesia	.63	....	....	....	0.33	
Sulphuric Acid	....	....	....	....	0.17	
Phosphoric Acid	.18	....	0.33	0.226	0.19	
Silicic Acid, or Silica	16.44	....	....	....	9.28	
Insoluble Silicious Matter	....	20.68				
Water, Combined	....	6.12				
Water, Total	7.16	....	....	....	8.74	
	100.39	....	....	....	99.91	
Metallic Iron	52.28	49.78	51.40	....	55.64	52.27
Phosphorus	.080	....	0.144	0.097	0.083	.094
Sulphur	....	....	....	....	0.068	
	Chemist, Brush. July 5, 1871. *Sampler*, Brooks.	*Chemist*, Britton. Nov. 4, 1871. *Sampler*, Brooks.	*Chemist*, Taylor. *Sampler*, Taylor.	*Chemist*, Wendel. *Sampler*,	*Chemist*, Chandler. May 14, 1866. *Sampler*, Brooks.	

NOTES.—49. Stock pile at Pioneer Furnace, Negaunee, Mich. 87. From mine, numerous fragments. 270. Stock pile at Cleveland. 26. From mine when first opened.

JACKSON MINE—*Specular Ore.*

	24.	24.	24.	51.	230.	230.	230.	*Averages.*
Sesqui- or Peroxide of Iron	93.75							
Oxide of Manganese	trace.	....	....	0.60				
Alumina	0.73							
Lime	0.61							
Magnesia	0.23							
Sulphur	0.03	....	....	0.18				
Phosphoric Acid	0.32	0.127	....	0.10	0.144			
Silicic Acid, or Silica	3.27	....	....	1.45				
Water, Total	1.09							
Alumina, Lime, Magnesia, Water, etc	....	....	....	1.67				
	100.03							
Metallic Iron	65.62	....	....	....	....	61.810	....	63.715
Phosphorus	0.14	0.055	0.069	0.04	0.063	0.078	0.073	.066
Sulphur	0.03	....	....	0.18				
Specific Gravity	....	....	....	....	4.95			
	Chemists, Chandler & Cairns. Mar. 9, 1872. *Sampler*, Brooks.	*Chemist*, Wuth. *Sampler*, Brooks.	*Chemist*, Britton. Dec. 20, 1872. *Sampler*, Brooks.	*Chemist*, Chandler. July 13, 1871. *Sampler*, Brooks.	*Chemist*, Wuth. *Sampler*, Brooks.	*Chemist*, Britton. Feb. 18, 1873. *Sampler*,	*Chemist*, Allen. *Sampler*,	

NOTES.—24. Large stock pile in Cleveland. 51. Stock pile at Pioneer Furnace, Negaunee, Mich. 230. Slate ore. West end of mine.

JACKSON MINE—*Hematite and Jaspery Ores.*

	231.	231.	231.	229.	229.	229.	*Averages.*
Phosphoric Acid	0.316	0.523	....	....	0.338	0.054	
Metallic Iron	....	59.30	54.530	56.590	58.20	....	57.155
Phosphorus	0.138	0.224	0.154	0.061	0.144	0.023	.124
Specific Gravity	4.20	....	....	4.59			
	Chemist, Wuth. 1872. *Sampler,* Brooks.	*Chemist,* Wendel. Feb. 6, 1873. *Sampler,*	*Chemist,* Britton. Feb. 18, 1873. *Sampler,*	*Chemist,* Britton. Feb. 18, 1873. *Sampler,* Brooks.	*Chemist,* Wendel. Feb. 6, 1873. *Sampler,*	*Chemist,* Wuth. *Sampler,*	

NOTES.—231. Hematite ore—west part of mine. 229. Old Pioneer opening—Jaspery ore. The Hematite and Specular ores occur together in this mine.

KLOMAN MINE—*Specular Ore.*

	235.	225.	*Averages.*
Metallic Iron	63.55	....	63.55
Phosphorus	0.097	0.081	.089
Specific Gravity	4 90		
	Chemist, Britton. *Sampler,* Brooks.	*Chemist,* Allen. *Sampler,*	

NOTE.—235. Fragments broken from outcrop, before work began.

LAKE SUPERIOR MINE—*Specular Ore.*

	37.	37.	37.	261.	261.	44.	274.	*Averages.*
Sesqui- or Peroxide of Iron	86.70							
Oxide of Manganese	trace.							
Alumina	1.64							
Lime	0.57							
Magnesia	0.24							
Sulphur	0.02							
Phosphoric Acid	0.14	0.075	......	0.24	0.239			
Silicic Acid, or Silica	9.82							
Water Total	0.61							
	99.74							
Metallic Iron	60.69	......	......	63.50	......	64.37	59.89	62.11
Phosphorus	0.06	0.033	0.046	0.103	0.102	0.10	.065	.078
Sulphur	0.02							
Specific Gravity	4.55						4.69	
	Chemists, Chandler & Cairns, Mar. 9, 1872. *Sampler,* Brooks.	*Chemist,* Wuth. *Sampler,*	*Chemist,* Britton. *Sampler,*	*Chemist,* Taylor. *Sampler,* Taylor.	*Chemist,* Wendel. *Sampler,*	*Chemist,* Britton. *Sampler,* John Fritz.	*Chemist,* Britton, Dec., 1872. *Sampler,* Brooks.	

NOTES.—37. Large Stock pile in Cleveland. 261. Stock pile at Cleveland. 44. Stock pile at Bethlehem Furnace. 274. Lower bed. Pit No. 1. Pennsylvania mine.

LAKE SUPERIOR MINE—*Hematite.*

	10.	10.	10.	269.	269.	276.	276.	87.	*Averages.*
Sesqui- or Peroxide of Iron	79.80								
Oxide of Manganese	0.10								
Alumina	2.05								
Lime	0.45								
Magnesia	0.53								
Sulphur	0.03								
Phosphoric Acid	0.30	0.104	.....	0.24	0.237	......	0.668		
Insoluble Silicious Matter	......	......	......	......	......	......	......	15.42	
Silicic Acid, or Silica	12.52	......	......	......	......	......	......	......	
Water, Combined	4.11	......	......	......	......	......	......	4.66	
" Uncombined	0.14								
	100.03								
Metallic Iron	55.86	......	......	52.00	......	......	......	55.00	54.28
Phosphorus	0.13	0.045	0.066	0.103	0.101	0.131	0.286	......	.130
Sulphur	0.03								
Metallic Manganese	0.07								
Specific Gravity	4.12								
	Chemists, Chandler & Cairns. March 4, 1872. *Sampler,* Brooks.	*Chemist,* Wuth. *Sampler,*	*Chemist,* Britton. *Sampler,*	*Chemist,* Taylor. *Sampler,* Taylor.	*Chemist,* Wendel. *Sampler,*	*Chemist,* Britton. Dec. 31, 1872. *Sampler,* Brooks.	*Chemist,* Wendel. Feb. 6, 1873. *Sampler,*	*Chemist,* Britton. Nov. 4. 1871. *Sampler,* Brooks.	

NOTES.—10. Large Stock pile at Cleveland. 269. Stock pile at Cleveland. 276. Hematite workings of mine.

LAKE ANGELINE—*Specular Ore (Jaspery).*

	21.	21.	267.	267.	34.	*Averages.*
Sesqui- or Peroxide of Iron	72.00	....	....	....	85.43	
Oxide of Manganese	trace.					
Alumina	0.92	....	....	....	1.89	
Lime	0.33	....	....	....	0.24	
Magnesia	0.34	....	....	....	0.13	
Sulphur	0.02	....	....	....	none.	
Phosphoric Acid	0.08	0.101	0.04	0.083	none.	
Silicic Acid, or Silica	25.09	....	....	....	12.31	
Water, Combined	1.09					
" Uncombined	0.12					
	99.99	....	....	....	100.00	
Metallic Iron	50.40	....	52.00	....	59.08	53.83
Phosphorus	0.03	0.044	0.017	0.036	none.	.031
Sulphur	0.02					
Specific Gravity	3.97					
	Chemists, Chandler & Cairns. March 4, 1872. *Sampler,* Brooks.	*Chemist,* Wuth. 1872. *Sampler,*	*Chemist,* Taylor. 1872. *Sampler,* Taylor.	*Chemist,* Wendel. 1872. *Sampler,*	*Chemist,* Wuth. Dec. 29, 1865. *Sampler,* Unknown.	

NOTES.—21. Stock pile in Cleveland. 267. Stock pile in Cleveland.

LAKE ANGELINE MINE—*Hematite.*

	268.	268.	280.	*Averages.*
Phosphoric Acid	0.09	0.160		
Metallic Iron	51.40	......	50.000	50.70
Phosphorus	.038	0.070	0.104	.079
	Chemist, Taylor. 1872. *Sampler,* Taylor.	*Chemist,* Wendel. *Sampler,*	*Chemist,* Britton. Dec. 31, 1872. *Sampler,* Brooks.	

NOTES.—268. Stock pile at Cleveland. 280. Stock pile at mine.

MICHIGAMME MINE—*Magnetic Ore.*

	1.	197.	225.	225.	225.	*Averages.*
Protoxide of Iron	......	29.109				
Sesqui- or Peroxide of Iron	......	61.631				
Protoxide of Manganese	1.01	traces.				
Alumina	2.12	2.120				
Lime	.12	1.070				
Sulphur	......	0.002				
Sulphuric Acid	......	0.008				
Phosphoric Acid	.05	0.057	0.067	......	0.392	
Silicic Acid, or Silica	3.06	3.280				
Water, Total	.57	1.497				
Organic or Carbonaceous Matter	......	0.340				
Titanic Acid	......	0.032				
Copper and Carbonic Acid	......	none.				
		99.146				
Metallic Iron	......	65.767	......	......	63.01	64.388
Phosphorus	0.027	0.024	0.029	0.019	0.168	.041
Sulphur	......	0.005				
Specific Gravity	......	......	4.61			
	Chemist, Britton. Sept. 21, 1870. *Sampler,* Brooks.	*Chemist,* Ralph Crooker, Boston. *Sampler,* Ralph Crooker.	*Chemist,* Wuth. 1872. *Sampler,* Brooks.	*Chemist,* Britton. 1872. *Sampler,* Brooks.	*Chemist,* Wendel. Feb. 6, 1873. *Sampler,* Brooks.	

NOTES.—1. Drill mud from 3 holes. 197. Numerous fragments from Exploration pits. 225. Taken at mine, fragments after blasting. All were taken before mine was opened.

MACOMBER MINE—*Hematite.*

	35.	35.	87.	*Averages.*
Sesqui- or Peroxide of Iron	76.80			
Oxide of Manganese	2.06			
Alkalies (by difference)	3.47			
Sulphur	0.14			
Phosphoric Acid	0.15	0.130		
Silicic Acid, or Silica	14.64			
Insoluble Silicious Matter	......	......	14.51	
Water, Combined	......	......	2.23	
Water, Total	2.74			
	100.00			
Metallic Iron	53.76	......	56.08	54.92
Phosphorus	0.06	0.057	......	0.058
Sulphur	0.14			
Metallic Manganese	1.51			
	Chemist, Chandler. Oct. 6, 1871. *Sampler,* Brooks.	*Chemist,* Wuth. *Sampler,*	*Chemist,* Britton. Nov. 4, 1871. *Sampler,* Brooks.	

NOTES.—35. From two trains of 16 cars each, one month apart. 87. From Mine. Numerous fragments. This mine belongs to the Negaunee hematite group, and contains considerable manganese.

MAGNETIC MINE—*Magnetic Flag Ore.*

	69.	54.	232.	232.	*Averages.*
Proto-sesquioxide of Iron	78.35	78.42			
Oxide of Manganese	0.10	trace.			
Alumina	trace.	.43			
Lime	0.69	.19			
Magnesia	0.21	.17			
Sulphur	0.58	none.			
Phosphoric Acid	0.151	.13			
Insoluble Silicious Matter	19.64	19.44			
Soluble Silica	......	.41			
Water, Total	......	0.42			
Undetermined and Loss	0.279	0.39			
	100.000	100.00			
Metallic Iron	55.16	56.78	52.22	......	54.72
Phosphorus	0.066	0.057	0.087	0.071	.067
Sulphur	......	none.			
Specific Gravity	......	......	4.30		
	Chemist, Jenney. 1872. *Sampler,* Brooks.	*Chemist,* Britton. Nov. 21, 1870. *Sampler,* Brooks.	*Chemist,* Britton. 1872. *Sampler,* Brooks.	*Chemist,* Allen. Jan. 1, 1873. *Sampler,*	

NOTES.—69. From small stock pile at mine. 54. From layers of rich ore banded with rock. From outcrop. 232. Small stock pile at mine.

MENOMINEE IRON REGION—*Specular Ores and Hematites.*

	95.	98.	102.	246.	74.	254.	68.	68.
Sesqui- or Peroxide of Iron	47.27	78.30	......	......	80.63	......	81.35	
Oxide of Manganese	......	......	......	......	3.075	......	1.32	
Alumina	......	......	......	......	......	......	trace.	
Lime	......	0.53	......	......	......	......	0.41	
Magnesia	......	0.17	......	......	......	......	0.237	
Sulphur	......	......	......	......	......	......	0.14	
Phosphoric Acid	......	0.044	......	......	......	......	......	0.260
Silicic Acid, or Silica	......	19.52	......	......	......	......	12.043	
Insoluble Silicious Matter	50.22	......	......	......	15.54			
Water, Total	......	......	......	......	......	......	3.498	
		98.564			99.245			
Metallic Iron	33.09	54.81	53.742	37.720	56.44	44.720	56.944	
Phosphorus	......	0.019	......	0.053	......	0.033	......	0.113
Metallic Manganese	......	......	......	......	0.735	......	0.313	
Specific Gravity	......	......	......	3.45	......	3.83		
	Chemist, Jenney. 1872. *Sampler*, Brooks.	*Chemist*, Wuth. Sept. 19, 1871. *Sampler*, Brooks.	*Chemist*, Chandler. *Sampler*, R. Pumpelly.	*Chemist*, Britton. *Sampler*, Brooks.	*Chemist*, Jenney. 1872. *Sampler*, Brooks.	*Chemist*, Britton. *Sampler*, Brooks.	*Chemist*, Jenney. 1872. *Sampler*, Brooks.	*Chemist*, Wuth. *Sampler*,

NOTES.—95. Average of prevailing variety of lean ore, Sect. 31, T. 42, R. 29. 98. Average of five of the richest pieces found, S. 31, T. 42, R. 29. 102. Average of 10 analyses for P. S. and L. S. Ship Canal Co., Sect. 31, T. 42, R. 29. 246. Same as 95. 74. Boulders at west ¼ post, Sect. 10. T. 39, R. 29. 68. From outcrop in swamp, Sect. 13, T. 42, R. 23. 254. Slate ore south ¼ post, Sect. 30, T. 40, R. 30.

MISSOURI—IRON MOUNTAIN MINE—*Specular Ore.*

	127.	127.	127.	128.	128.	128.	*Averages.*
Sesqui- or Peroxide of Iron	93.57	....	....	95.42			
Proto-sesquioxide of Iron	0.76	....	....	0.86			
Alumina	0.08	....	....	0.06			
Lime	0.46	....	....	0.32			
Magnesia	0.23	....	....	0.21			
Sulphur	....	....	0.008	....	....	.012	
Phosphoric Acid	0.035	....	0.112	0.036	....	0.067	
Silicic Acid, or Silica	4.75	....	....	3.02			
Metallic Manganese	0.12	....	....	0.07			
	100.005	....	....	99.996			
Metallic Iron	66.049	....	....	67.416	....	....	66.732
Phosphorus	0.016	0.043	0.049	0.016	0.025	.029	.029
Sulphur	....	....	0.008	....	....	.012	.010
Metallic Manganese	0.12	....	....	0.07	....	....	.095
Specific Gravity	4.944	....	....	5.002			
	Chemist, Wuth. April, 1872. *Sampler*, Brooks.	*Chemist*, Allen. May, 1872. *Sampler*, Brooks.	*Chemist*, A. A. Blair. 1872. *Sampler*, Brooks.	*Chemist*, Wuth. April, 1872. *Sampler*, Brooks.	*Chemist*, Allen. *Sampler*,	*Chemist*, A. A. Blair. *Sampler*,	

NOTES.—127. "Quarry Ore." Chippings from all parts of the pit and Stock piles. 128. "Surface Ore" (Boulders). Chippings and pebbles from all the diggings and Stock piles.

NEW YORK MINE—*Specular Ore.*

	20.	20.	20.	237.	237.	238.	238.	*Averages.*
Sesqui- or Peroxide of Iron	90.00							
Oxide of Manganese	trace.							
Alumina	1.87							
Lime	1.20							
Magnesia	0.60							
Sulphur	0.03							
Phosphoric Acid	0.57	0.428						
Silicic Acid, or Silica	4.72							
Water, Total	0.98							
	99.97							
Metallic Iron	63.00	......	......	62.13	......	60.10	......	61.74
Phosphorus	0.22	0.187	0.204	.1385	0.151	0.326	0.326	.225
Sulphur	0.03							
Specific Gravity	4.64	......	......	4.88	......	4.63		
	Chemists, Chandler & Cairns. March 4, 1872. *Sampler*, Brooks.	*Chemist*, Wuth. *Sampler*,	*Chemist*, Britton. *Sampler*,	*Chemist*, Britton. September, 1872. *Sampler*, Brooks.	*Chemist*, Allen. *Sampler*,	*Chemist*, Britton. March, 1873. *Sampler*, Brooks.	*Chemist*, Allen. *Sampler*,	

NOTES.—20. Large Stock pile at Cleveland—all varieties. 237. Great South Opening—Pit No. 1. 238. Beardsley's Pit—No. 2. The two last from mine.

NEW ENGLAND MINE—*Soft Hematite.*

	87.	239.	*Averages.*
Sulphur	....	None.	
Insoluble Silicious Matter	25.66	23.30	
Water Combined	1.42		
Volatile Matter (a little organic and water)	....	2.69	
Metallic Iron	49.64	46.84	48.24
Phosphorus	....	0.08	.08
Sulphur	....	none.	
Metallic Manganese	....	0.18	
Specific Gravity	....	3.79	
	Chemist, Britton. Nov. 4, 1871. *Sampler*, Brooks.	*Chemist*, Britton. December 27, 1872. *Sampler*, Brooks.	

NOTES.—87. From mine, numerous fragments. 239. From cars and stock pile at mine. First-class specular ore was formerly mined here, but is not at present.

NEGAUNEE HEMATITES—*Manganiferous Soft Hematite.*

	243.	243.	243.	11.	11.	108.	116.	*Averages.*
Sesqui- or Peroxide of Iron	......	......	......	65.40	......	65.48		
Oxide of Manganese	......	......	......	6.71	......	1.54		
Alumina	......	......	......	1.46				
Lime	......	......	......	0.45				
Magnesia	......	......	......	0.66				
Sulphur	......	......	......	0.04				
Phosphoric Acid	......	......	......	0.16	0.171			
Silicic Acid, or Silica	......	......	......	22.67	.....	29.25		
Water Combined	......	......	......	1.88				
" Uncombined	......	......	......	0.58				
				100.01				
Metallic Iron	......	35.00	......	45.78	......	45.83	50.58	44.29
Phosphorus	0.067	0.065	0.099	0.07	0.074	......	......	.074
Sulphur	......	......	......	0.04				
Metallic Manganese	0.42	......	......	4.67	......	1.03	......	2.04
Specific Gravity	3.47	......	......	3.83				
	Chemist, Jenney. 1872. *Sampler,* Brooks.	*Chemist,* Britton. 1872. *Sampler,*	*Chemist,* Allen. 1872. *Sampler,*	*Chemists,* Chandler & Cairns. Mar. 4, 1872. *Sampler,* Brooks.	*Chemist,* Wuth. 1872. *Sampler,*	*Chemist,* Chandler. June 29, 1872. *Sampler,* Brooks.	*Chemist,* Jenney. July 13, 1872. *Sampler,* Brooks.	

NOTES.—243. From exploration pits. 11. Small stock pile at Cleveland. 108. Average of three analyses of ore from exploration pits. 116. Dark brown chalky ore. All from Sects. 6, 7, and 8, T. 47, R. 26.

NEW YORK STATE ORES (ST. LAWRENCE & WAYNE CO.)—*Hematites.*

	203.	206.	205.	204.	215.	209.
Protoxide of Iron	....	....	12.49	12.72		
Sesqui- or Peroxide of Iron	75.30	77.24	56.54	57.93	63.31	
Protoxide of Manganese	0.15	....	trace.	0.07		
Alumina	1.69	0.45	0.69	4.54		
Lime	7.04	1.60	8.23	2.32	6.03	
Magnesia	0.38	0.23	2.13	0.85		
Sulphur	0.03	0.05	none.	0.07		
Phosphoric Acid	trace.	trace.	0.36	0.16		
Silicic Acid, or Silica	10.12	....	4.28	10.97	....	1.49
Insoluble Silicious Matter	....	12.93				
Water, Total	....	2.107	....	0.62		
Carbonic Acid	5.41	....	15.01	9.75		
	100.12	94.607	99.73	100.00		
Metallic Iron	52.71	54.07	49.30	50.23	44.31	41.80
Phosphorus	....	....	0.16	0.07	0.43	0.64
	Chemists, Maynard & Wendel. Mar., 1871. *Sampler,* Geo. W. Maynard.	*Chemist,* Jenney. 1872. *Sampler,* Brooks. Jan. 1871.	*Chemists,* Maynard & Wendel. *Sampler,* Geo. W. Maynard.	*Chemists,* Maynard & Wendel. *Sampler,* Geo. W. Maynard.	*Chemist,* Chandler. *Sampler,* Unknown.	*Chemist,* Taylor. Jan. 2, 1873. *Sampler,* Geo. R. Tuttle.

NOTES.—203. Sampled for John A. Griswold & Co., at mine. 204. Do. do. 205. Do. do. 206. From small stock pile at Cleveland. 215. Analysis furnished by H. B. Tuttle. 203 and 206 are from Keene Mine. 204 and 205 are from the Caledonia Mine, both owned by Rossie Iron Works. 209 and 215 are Wayne Co. ore.

NEW YORK (LAKE CHAMPLAIN REGION)—*Magnetic.*

	288.	289.	290.	291.	292.
Protoxide of Iron	26.69	25.35	23.29	8.87	19.05
Sesqui- or Peroxide of Iron	59.84	56.19	50.13	69.99	42.97
Protoxide of Manganese	.55	0.12	0.38	0.38	
Alumina	1.87	3.56	4.22	3.67	3.47
Lime	....	0.82	1.28	1.90	1.19
Magnesia	....	....	0.85	traces.	0.09
Sulphur	.20	....	....	0.24	
Phosphoric Acid	1.94	trace.	trace.	0.07	trace.
Silicic Acid, or Silica	3.45	12.34	20.02	14.60	32.94
Water, Total	....	0.47			
Carbonate of Lime	6.02				
	100.56	98.85	100.17	99.72	99.71
Metallic Iron	62.61	59.02	53.21	55.91	44.98
	Chemist, Geo. W. Maynard. *Sampler,* Geo. W. Maynard.	*Chemist,* Geo. W. Maynard. *Sampler,* Geo. W. Maynard.	*Chemist,* Geo. W. Maynard. *Sampler,* Geo. W. Maynard.	*Chemist,* Geo. W. Maynard. *Sampler,* Geo. W. Maynard.	*Chemist,* Geo. W. Maynard. *Sampler,* Geo. W. Maynard.

NOTES.—288. Wetherby, Sherman & Co., and Port Huron Iron Ore Co., No. 21. 289. New Bed; Wetherby, Sherman & Co. 290. Hammond, Crown Point. 291. Indian; Ferrona ore; Hassey, Wells & Co. 292. Fisher; Port Henry Iron Ore Co.

OHIO IRON ORES—*Black Band and Kidney.*

	293.	294.	295.	296.	297.	298.	*Averages.*
Protoxide of Iron	26.82	23.02					
Sesqui- or Peroxide of Iron	8.94	8.79	75.00	7.60	75.00	12.34	
Oxide of Manganese	1.00	1.70	1.65	1.35	1.85	1.70	
Alumina	trace.	0.70	0.60	2.60	0.60	0.50	
Lime	1.05	1.70	2.80	....	5.94	....	
Magnesia	0.97	0.88	1.48	carbo. 6.50	3.64	carbo. 5.33	
Sulphur	0.18	0.11	trace.	0.18	0.12	trace.	
Phosphoric Acid	trace.	0.492	0.773	0.863	1.26		
Silicic Acid, or Silica	11.84	26.22	17.02	8.96	8.46	11.94	
Water, Combined	......	......	......	....	2.28	.78	
Water, Total	......	......	0.25				
Volatile Matter	30.50	21.10					
Carbonic Acid	18.30	15.00					
Lime Phosphate	......	......	......	....	......	1.74	
Lime Carbonate	......	......	......	7.35	......	8.59	
Iron Carbonate	......	......	......	64.17	......	56.23	
	99.60	99.712	99.573	99.573	99.15	99.15	
Metallic Iron	27.12	24.06	52.50	36.31	52.50	35.88	
Phosphorus	.....	0.216	0.34	0.379	0.554	0.797	
Specific Gravity	2.494	2.321	3.411	3.434	4.076	2.539	
	Chemist, T. G. Wormley. *Sampler.*	*Chemist,* T. G. Wormley. *Sampler,*	*Chemist,* T. G. Wormley. *Sampler,*	*Chemist,* T. G. Wormley. *Sampler,*	*Chemist.* *Sampler.*	*Chemist.* *Sampler.*	

NOTES.—293. Black Band, Mineral Ridge, Mahoning Co., O. 294. Black Band, Tuscarawas Coal and Iron Co., Tuscarawas Co., O. Raw. 295. Black Band, Tuscarawas Coal and Iron Co., Tuscarawas Co., O. Calcined. 296. "Shell" or "Kidney Ore," Tuscarawas Coal and Iron Co., Tuscarawas Co., O. Raw. 297. "Shell" or "Kidney Ore," Tuscarawas Coal and Iron Co., Tuscarawas Co., O. Calcined. 298. Nodular Ore, Washingtonville Co., Columbiana Co., O.

For further analyses of Ohio Iron Ores, consult *Geological Survey of Ohio*, 1870, pp. 47, 48, 49, 219, 223.

REPUBLIC MINE—*Specular and Magnetic.*

	233.	233.	234.	234.	Averages.
Metallic Iron	67.21	......	65.81	......	66.51
Phosphorus	0.03	0.025	0.061	0.045	.040
Specific Gravity	5.19	......	5.07	......	......
	Chemist, Britton. 1872. *Sampler*, Brooks.	*Chemist*, Allen. 1872. *Sampler*,	*Chemist*, Britton. 1872. *Sampler*, Brooks.	*Chemist*, Allen. 1872. *Sampler*,	

NOTES.—233. Specular ore. First stock pile at opening of mine. 234. Magnetic ore. First stock pile at opening of mine.

SAGINAW MINE—*Specular and Hematite.*

	281.	282.	Averages.
Metallic Iron	50.820	53.980	52.40
Phosphorus	0.184	0.080	.132
	Chemist, Britton. Jan. 9, 1873. *Sampler*, Brooks.	*Chemist*, Britton. Jan. 9, 1873. *Sampler*, Brooks.	

NOTES.—281. Small stock pile (first mined) at mine. 282. Ditto. Both samples are soft hematite. By oversight no sample of the specular ore, which is first-class, was collected.

SHENANGO MINE—*hematite.*

	242.	242.	78.	Averages.
Sesqui- or Peroxide of Iron	......	......	82.13	
Oxide of Manganese	......	......	.15	
Alumina	......	......	2.32	
Lime	......	......	.41	
Magnesia	......	......	.08	
Phosphoric Acid	......	......	.186	
Silicic Acid, or Silica	......	......	14.46	
Water, Combined	......	......	.26	
			99.996	
Metallic Iron	55.140	......	57.49	56.315
Phosphorus	.049	0.071	0.081	.070
Specific Gravity	3.60			
	Chemist, Britton. 1872. *Sampler*, Brooks.	*Chemist*, Allen. 1872. *Sampler*,	*Chemist*, Wuth. 1872. *Samplers*, Davock, Glidden & Co.	

NOTES.—242. From small stock pile at mine. 78. "Taken from under snow, with no possible selection."—Letter from Davock, Glidden & Co.

SILAS C. SMITH MINE—*Hematite.*

	70.	70.	87.	Averages.
Sesqui- or Peroxide of Iron	71.70			
Oxide of Manganese	0.10			
Alkalies	2.03			
Sulphur	0.27			
Phosphoric Acid	0.09	0.127		
Silicic Acid, or Silica	23.38			
Insoluble Silicious Matter	......	......	23.79	
Water, Total	2.43	......	2.43	
	100.00			
Metallic Iron	50.19	......	49.21	49.70
Phosphorus	0.04	0.055	......	.047
Sulphur	0.27			
	Chemist, Chandler. Sept. 7, 1871. *Sampler*, Brooks.	*Chemist*, Wuth. *Sampler*,	*Chemist*, Britton. Nov. 4, 1871. *Sampler*, Brooks.	

NOTES.—70. From small stock pile at mine when first opened. 87. From mine when first opened, numerous fragments.

SPURR MOUNTAIN MINE—*Magnetic Ore.*

	2.	226.	226.	226.	97.	Averages.
Proto-sesquioxide of Iron	89.21	......	......	......	92.36	
Oxide of Manganese	traces.	......	......	......	0.15	
Alumina	2.67	......	......	......	1.66	
Lime	.67	......	......	......	0.73	
Magnesia	0.19	......	......	......	0.75	
Sulphur	0.35					
Phosphoric Acid	trace.	0.259	......	......	0.221	
Silicic Acid, or Silica	6.28	......	......	......	4.31	
	99.37				100.181	
Metallic Iron	64.60	......	......	59.96	66.87	63.81
Phosphorus	......	0.113	0.112	......	0.096	.104
Sulphur	0.35					
Specific Gravity	......	4.62				
	Chemist, Chandler. Nov. 1868. *Sampler*, Brooks.	*Chemist*, Wuth. 1872. *Sampler*, Brooks.	*Chemist*, Britton. 1872. *Sampler*,	*Chemist*, Wendel. Feb. 6, 1873. *Sampler*,	*Chemist*, Wuth. Sept. 14, 1872. *Samplers*, Morgan & Herne.	

NOTES.—2. Numerous fragments broken from outcrops of ore. 226. Fragments broken from outcrop 97 Numerous fragments broken from outcrop. All before mine was opened.

TAYLOR MINE—L'ANSE RANGE—*Hematite.*

	88.	81.	89.	89.	87.	*Averages.*
Sesqui- or Peroxide of Iron	82.664	....	62.25			
Oxide of Manganese	0.894	....	1.87			
Alumina	....	....	3.028			
Lime	0.312	....	0.31			
Magnesia	0.226	....	0.26			
Sulphur	0.090	....	trace.			
Phosphoric Acid	0.236	....	0.31			
Silicic Acid, or Silica	6.180					
Insoluble Silicious Matter	....	10.75	21.30	....	5.29	
Water, Combined	....	....	....	....	8.70	
" Total	9.438	9.41	8.10			
	100.040		97.428			
Metallic Iron	57.86	52.00	43.576	44.78	57.51	52.88
Phosphorus	0.102	....	0.13	0.097	....	.107
Sulphur	0.090					
Metallic Manganese	0.62	....	0.45	....	....	.53
	Chemists, Chandler & Schweitzer. *Sampler,* Brooks.	*Chemist,* Britton. 1871. *Sampler,* Brooks.	*Chemist,* Jenney. 1872. *Sampler,* Brooks.	*Chemist,* Britton. Feb. 18, 1873. *Sampler,*	*Chemist,* Britton. *Sampler,* Brooks.	

NOTES.—88. From shaft 20 feet in ore. 81. From three trenches across ore deposit. 89. From all pits, shafts and trenches showing ore. 87. From mine, numerous fragments. All before mine was opened.

WASHINGTON MINE—*Magnetic Ore.*

	39.	39.	39.	264.	264.	284.	285.	*Averages.*
Proto-sesquioxide of Iron	91.06							
Oxide of Manganese	0.23							
Alumina	0.85							
Lime	0.92							
Magnesia	0.77							
Sulphur	0.03							
Phosphoric Acid	0.25	0.406	......	0.21	0.170			
Silicic Acid, or Silica	5.13							
Water, Total	0.66							
	99.90							
Metallic Iron	65.94	......	......	67.20	......	57.280	54.800	61.305
Phosphorus	0.11	0.177	0.149	0.09	0.073	0.195	0.146	.141
Sulphur	0.03							
Metallic Manganese	0.14							
Specific Gravity	4.66							
	Chemists, Chandler & Cairns. March, 1872. *Sampler,* Brooks.	*Chemist,* Wuth. 1872. *Sampler,*	*Chemist,* Britton. 1872. *Sampler,*	*Chemist,* Taylor. 1872. *Sampler,* Taylor.	*Chemist,* Wendel. 1872. *Sampler,*	*Chemist,* Britton. Jan. 9, 1873. *Sampler,* Brooks.	*Chemist,* Britton. Jan. 9, 1873. *Sampler,* Brooks.	

NOTES.—39. Large stock pile in Cleveland. 264. Stock pile at Cleveland. 284. Shafts Nos. 1 and 4 at mine. 285. Shafts Nos. 2 and 6 at mine.

WINTHROP MINE—*Soft Hematite.*

	240.	240.	287.	*Averages.*
Sesqui- or Peroxide of Iron	....	....	84.66	
Protoxide of Manganese	....	....	1.41	
Alumina	....	....	0.13	
Lime	....	....	0.40	
Magnesia	....	....	0.007	
Sulphur	....	....	0.02	
Phosphoric Acid	....	....	0.084	
Silicic Acid, or Silica	....	....	12.70	
Insoluble Silicious Matter	24.34			
Water, Total	....	....	0.71	
Volatile Matter	0.93			
			100.121	
Metallic Iron	50.00	....	59.26	54.63
Phosphorus	0.03	0.045	0.037	.037
Sulphur	none.			
Metallic Manganese	0.53			
Specific Gravity	4.03			
	Chemist, Britton. Dec. 26, 1872. *Sampler,* Brooks.	*Chemist,* Allen. *Sampler,*	*Chemist,* Fred. H. Emmerton. Feb. 13, 1873. *Sampler,* J. T. Torrence.	

NOTES.—240. From all parts of mine. 287. Stock pile at a Chicago furnace.

WISCONSIN IRON ORES—*Iron Ridge* (*Hematite*).

	298.	*Averages.*
Pure Metallic Iron	56.44	
Oxygen with the Iron	24.91	
Protoxide of Manganese	.47	
Alumina	2.30	
Lime	2.28	
Magnesia	.99	
Sulphuric Acid	.15	
Phosphoric Acid	1.10	
Insoluble Silicious Matter	3.57	
Soluble Silica	.75	
Water and Carb. Acid	6.30	
	99.26	
Metallic Iron	56.44	
Phosphorus	.48	
Sulphur	.06	
	Chemist, J. B. Britton. *Sampler,* J. J. Hagerman.	

NOTE.—298. The ore is a fossil ore, in grains about the size and shape of flax-seed; Dr. Topham calls it Oolitic ore. There are several old analyses showing no phosphorus, but they are not reliable.

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