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COMBINATION
IN THE
MINING INDUSTRY:
A STUDY OF CONCENTRATION IN LAKE SUPERIOR
IRON ORE PRODUCTION

BY

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PREFACE

THIS essay is an attempt to explain the remarkable concentration which has taken place in the control of the Lake Superior iron mines during the past thirty years. The study is based upon such printed sources of information as are available and no effort has been made to investigate at first hand present conditions in the mining industry. Since the theory offered is based upon incomplete data, its conclusions may be subject to modification upon further investigation. It is presented at this time in the hope that it may throw some light on the problem of the development of monopoly.

H. R. M.

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CHAPTER I

THE THEORY OF CONCENTRATION

§ 1. The making of iron and steel is pre-eminently the industry of large capital. It has advanced faster and farther along the line of capitalistic development than any other manufacturing industry, and it thus illustrates clearly the tendencies inherent in large-scale production. To understand the economics of steel, therefore, would be to comprehend the laws whose working is likely to control the world of business in the immediate future. The present essay is an attempt to study some of those laws as exemplified in one particular phase of the steel industry, the concentration of Lake Superior ore production in the hands of a few great corporations.

Every industry is a combination of labor, natural resources and capital. Both in manufactures and in extractive industry capital grows rapidly in importance as compared with the other two agents; but in the extractive industries, and particularly in mining, such growth is attended by certain distinctive and important results which it is proposed to investigate.

The theory here suggested is as follows: With the growth of capital the control of the mines is inevitably concentrated in a few hands, and the process of growth and concentration if carried to its logical conclusion must result in monopoly. The price of ore is continually reduced by the action of forces over which the producer has no control.

At the same time the mines constantly grow deeper, and the natural cost of production is correspondingly raised. The producer, unable to raise the price, must reduce the cost; and as such reduction requires more capital, the weaker producers are steadily crowded to the wall, and their mines pass into the hands of stronger companies. Though the amount of capital necessary to work the individual mine is rapidly increased, yet in various ways, to be hereafter described, the amount controlled by individual companies rises even faster. Therefore the single company can operate economically not one mine or two, but a dozen, a score, a hundred. As the discovery of new mines does not keep pace with this increasing ability of the stronger companies, the field is divided up among a constantly diminishing number of large concerns. The logical result of this process is that when one corporation has capital enough for the economical working of the entire deposits it will obtain sole control. It is not maintained, of course, that the logical result will necessarily be the actual one.

The theory will now be stated in detail. It divides itself naturally into four parts, namely: (*a*) The decline of prices. (*b*) The increase in the cost of production. (*c*) The compulsory application of capital to counteract such increase in cost. (*d*) The consequent monopolization of the mines. These four points will be considered in order.

§ 2. The price of ore, like that of any other raw material, depends upon its anticipated value to the maker of finished goods—in this case pig-iron. But pig-iron, it should be observed, is only the raw material for the manufacture of iron and steel, and as such gets its value from the expected price of finished goods, as rails, sheets, plates, structural shapes, castings, machinery and other products. But even this statement does not go to the bottom of the matter, for prices of finished iron and steel goods, which are almost

entirely instruments of further production, are peculiarly sensitive to those fluctuations of demand which accompany the alternations of good and bad times. It will thus be seen how long and how complicated is the series of causes which finally results in the fixing of ore prices. Any force which affects the price of these other goods or affects the demand for them, may, and usually does, have its influence on the price of ore.

It is matter of common knowledge that the price of iron and steel goods during the last fifty years has declined more or less steadily. Though it is impossible to trace here the causes of such decline, it is necessary to suggest them in a general way and to show how they have affected ore prices. Under the highly competitive conditions which have characterized the iron trade, every reduction of cost has meant, sooner or later, a corresponding reduction of price. The causes of cost reduction may be summed up under four main heads, namely: Improvements in methods, processes and machinery; improvements in organization; enlarged output per establishment; and the opening up of cheap new sources of raw material.

Concerning the first three changes, it is to be observed that if they took place at the same time in the works of all producers they would not necessarily depress the price of ore. In fact, by the reduction of price, and the consequent increased consumption of finished goods, they might enlarge the demand for the raw material and so raise the price. But such changes are introduced first into only one or two establishments, which thus secure an important differential advantage. The other producers, put at a disadvantage, must find a way to reduce cost, and in the effort they put pressure on the mine-owners to reduce the price of ore. If all the ore were sold freely in the open market, the manufacturer with a differential advantage might, in the process

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of increasing his output, bid up ore and thus take it away from his less fortunate rival; in this case improvements in manufacture would raise the price of ore. But as much of the ore is, in one way and another, committed to particular iron-makers, when any of the latter find themselves at a disadvantage in competition they are able to make the ore-producers bear a part of the burden. Thus improvements in the iron industry operate to depress the price of ore. The opening of new sources of supply lowers price, according to the ordinary principles of competition. In general, it may be said that ore prices, reflecting the course of values in the trade, must tend steadily downward, so long as competition does its work.

§ 3. Still another influence must be considered in connection with the course of general prices. While the reduction of cost above suggested might well result in a slow and gradual fall in price, keeping pace with the lowering of cost, as a matter of fact the method of price change is very different.

Because of the length of the productive series heretofore alluded to, the equipment that is building to-day may be intended to satisfy a demand that will not come into existence for a year or two. During a period of rising demand the plant under construction at any given time, if completed, would be in excess of that required to satisfy the demand actually existing at that time. If consumption rises according to expectation, the new equipment, when completed, will be no more than adequate to the demand which will then exist. But if the anticipated increase fails to occur, the equipment will be in excess of the requirement, and all the more true will this be if an actual decrease in demand takes place.

• The expected increase has repeatedly failed of accomplishment; a halt has invariably occurred after a few years of upward movement. The producer, naturally enough, has

been unable to foretell a year in advance when the increase of demand was going to cease; and therefore a periodic over-production of iron has occurred, accompanied by a violent fall in price. The price decline thus effected has forced upon all iron makers the sharpest possible retrenchment, and among other reductions they have cut down the price of their raw materials, coke and ore. Accordingly, the price of both finished goods and ore, instead of declining steadily, has gone down by a series of steps more or less irregular, separated from each other by successive crises in the trade.

The fact to be emphasized as the outcome of this entire discussion of price is that the ore-producer must face a condition of perpetually falling prices, quite irrespective of his particular cost of production.

§ 4. Turning now to the second part of the theory, we observe that there is a constant increase in the natural cost of production, by which is meant the expenditure of energy which would be necessary to get out ore but for improvements in methods and machinery.

Such increase is evident enough in the case of the individual mine. At first there were many hills in the iron region that were practically solid ore bodies. It was common to begin operations by blasting down huge masses from the ledges and carting them away. When, later, it became necessary to take the ore from a pit, it could still be hauled with a horse and cart, but only by going up an incline. This meant either smaller loads or more horses. The incline became longer and steeper as the mine was worked until it was impossible to get out the ore at all except by some kind of hoisting apparatus.

At last the open-pit method of mining had to be given up altogether and shafts were sunk from which drifts were run out to gain the ore. Underground work introduced many new difficulties and increased cost in manifold ways. Tim-

bering had to be used to support the roof; it was necessary to leave some of the ore for pillars; artificial light was required; the liability to accident was greatly increased; explosives were far less effective than when used in open works; and as the mines grew deeper they filled with water and compelled the operators to put in pumping and hoisting machinery. After underground work was once begun the deepening of the mines served only to increase the difficulties and expense of gaining ore.

As the natural cost increases for the single mine, so it rises for the entire region. The discovery of new mines and ranges indeed furnishes cheaply-worked ore, and the increase in cost for the whole region may thereby be delayed, may possibly be temporarily reversed, but it cannot be permanently prevented.

§ 5. This increase of cost, coupled with the fact that price does not rise correspondingly but on the contrary declines, as heretofore shown, destroys profits and obliges the producer by some means to bring cost within the limits imposed by price. The one way in which he can effect such a result is by the use of capital.

The decline of price does not press upon all companies with equal severity, nor does it immediately compel every operator to increase his capital. Those concerns which possess a marked differential advantage may continue to work for some time with the old methods. The most notable case of such advantage is found in the ownership of new mines which can be cheaply worked, and which may for a while lag behind in the march of improvement.

The older mines must put in better machinery or they cannot make money. Some of the companies have not resources sufficient to buy the necessary equipment, and they are forced to suspend operations and sell out to their stronger rivals. Other producers, amply provided with

funds, make liberal expenditures for new plant, thus reducing cost below the old figure and making production profitable even at a lower price.

§ 6. The economies effected by capital are familiar to every student. Of these the substitution of machinery for labor is of course the most important. In early days the horse and cart, the swing derrick and the winding-drum were universally employed in the mines. The steam-engine superseded them all and did their work at a quarter the cost, at the same time bringing about a revolution in methods of operation. The large and fast-working skip took the place of the small and clumsy bucket; the miners were comfortably carried up and down to their work instead of spending an hour or two each day (at the company's expense) laboriously climbing ladders; substantial wooden shaft-houses succeeded the crazy structures of early days, and were in turn replaced by permanent buildings of stone and steel; the hand drill, requiring two strikers and a turner, and at best hard to operate in close quarters, gave way to the power drill, which dispensed with most of the labor, worked many times more rapidly, and could be employed no matter how small the opening or how inconvenient the angle at which it was desired to attack the working face; nitroglycerine and dynamite were used instead of black powder; the painful carting of ore and rock over the uneven floor of the mine tunnel was given up; with improved grades, tracks were laid down and the "fifty-inch mule" drew the ore-cars through the low passage-ways; in the large mines and longer drifts the wire-rope haulage system and the electric larry were introduced; in place of the sputtering miner's lamp sending out an uncertain ray into the universal darkness, powerful electric lights illumined brightly the dark corners; and the mine, which in the early days was a mere hole from which ore and rock were blasted out and carted away with

no especial plan or thought, became a perfectly-equipped industrial machine embodying every possible labor-saving device.

Capital has cheapened cost not only by the direct economy of machinery, but by the enlargement of output. Lacking capital, every increase in the production of a mine means a proportionate, or even more than proportionate, rise of cost. But once provide a mine with the equipment for underground work, sink the shaft, build the spur to the railroad, instal the engines and pumps, and enlarged output is not attended by anything like a corresponding rise in cost. As in every industry employing large capital, the mine works under a law of increasing returns up to the point of full utilization of plant. The economy of production attained by spreading over a larger number of tons fixed charges for superintendence, for expert service, for exploration, for development work, for pumping and for interest, has done much during later years to counteract the higher cost due to the deepening of the mines.

Cost has likewise been cheapened by the employment of scientific methods throughout the mining industry. More accurate knowledge of the geology of the ore deposits has placed exploration on a fairly scientific basis, and systematic search for new properties has proved more profitable than the old haphazard method. This redounds to the advantage of the large companies, which alone can afford to carry on persistent exploration by trained men. Similarly, as metallurgical science has advanced, and physical and chemical requirements in blast-furnace practice have grown more exacting, the mining companies have been obliged to employ chemists, who test every skip-load of ore, and by this systematic sampling enable the producers to mix and grade their ores with a remarkable degree of nicety, and to satisfy the consumer by furnishing a product almost abso-

lutely uniform. Such expert service costs money. Only large output can warrant the added expense.

§ 7. If now we turn from the mining industry proper to ore transportation, we find capital even more potent. At an outlay of a million dollars the state constructed the canal which first made mining profitable; by the expenditure of additional millions the federal government deepened the canal to 16 and then to 20 feet, improving the river channel correspondingly. On 12 feet of water the largest lake vessel could not carry much more than a thousand tons; the 16-foot canal made possible the 3,000-ton steamer; while the ore-carriers building on the lakes to-day will bring down 10,000 tons at a voyage. This remarkable growth in the size of the lake vessel, in conjunction with the change from sail to steam power, has lowered the cost and price of water transportation until to-day a ton of ore is carried from the upper lakes to Cleveland for less than a fifth of what it cost to transport it thirty-five years ago.

A similar though smaller reduction has been effected on the railroads through the use of heavy locomotives, the substitution of large steel cars for the four-wheeled vehicles of early days, and the other familiar economies of modern railway practice.

Most marvelous of all are the changes which have taken place at the docks. The mere fact of enlargement has been important enough, but the most notable development has been the rapid evolution of machinery for loading and unloading. Thirty-five years ago it was a remarkable feat for all the docks at Marquette to load 6,000 tons in a day, and it required an hour and a half to load a 700-ton ship. At present a cargo of 10,000 tons can be loaded into a single vessel in ninety minutes. Such results are accomplished only by the use of powerful and expensive machinery.

§ 8. Machinery, large output, scientific methods, cheap

transportation—not only has capital made all these possible, but it has brought ore mining and transportation, in all their stages, under single management. Nay, it has gone even farther and placed under one hand also the smelting of the ore and the manufacture of pig-iron into finished goods.

In passing from the mine to the furnace the ore paid a long series of profits: First, in many cases, to the miner who worked on contract; second, to the mining company; third, to the railroad which hauled the ore to the lake; fourth, to the contractor who loaded and unloaded it at the docks; fifth, to the vessel which took it down the lakes; sixth, to the agent who sold it on commission; and seventh, to the railroad which carried it from the lake to the blast-furnace. When the companies became strong enough they determined to save these profits for themselves, and by purchasing railroads and steamships and by handling their own product from mine to furnace they effected a notable reduction in the expense of laying down ore at the lower lake ports.

§ 9. As was said before, the use of capital in these various ways is not undertaken by all the companies at once, those producers having a differential advantage often being slower to make improvements. The increasing tendency to large output, however, quickly exhausts the cheap surface workings, and if a company wishes to exist longer than a season or two it must promptly adopt the capitalistic methods of the older producers. Hence, the small companies are perpetually weeded out, the financial standard of survival is continually raised, and the struggle is waged only by larger and stronger competitors.

§ 10. The application of capital, like the fall of price, is a more or less irregular and spasmodic process, and this because it is in no small part forced upon producers by the price decline and the consequent necessity for lower cost.

The reduction of cost has been a more nearly continuous process than the fall of price; yet the most notable changes in the cost level have been made shortly after those times when prices have gone down sharply, and such changes have been effected chiefly by rather sudden enlargement in the amount of capital employed. We may accordingly divide the history of the Lake Superior region into three main periods according to the amount of capital used in working the typical individual mine.

The period of small capital extends from the opening of the mines up to the crisis of '73. During this time the operating companies invested very little money in their mines, as prices were high, the scale of operations was small and the ore deposits were rich and cheaply wrought. This we shall call the period of exploitation.

With the exhaustion of the surface workings came the necessity for underground operations, and with the lower prices of the years following 1873 cheaper mining became necessary. In consequence the amount of capital employed in the mines rose steadily during the next twenty years, while the extension of demand and the discovery of new ranges progressively enlarged the sphere of operations, thus preventing the development of monopoly. This era of moderate capital is called the period of preparation, because while it was passing all things were making ready for those changes which during the last dozen years have concentrated the control of the mines in the hands of a few great companies.

The remarkable fall of prices in 1893 and the following years, with the consequent widespread ruin of ore companies, introduced the period of large capital and centralization. The steel companies had during the preceding period made a beginning in acquiring mines, with railroads and lake vessels to transport their product; now, fortified

by almost unlimited capital and possessing every facility for economical operation, they took advantage of the helpless state of the prostrate mining concerns, swooped down on their properties, poured into them vast amounts of capital for equipment, spent other large sums in improving transportation, and carried ore down to Cleveland at a figure that had never been approached in the history of the Lake Superior region. The economies attained during this period could have been realized only by companies possessing the enormous capital necessary for the ownership of mines, railroads and steamships.

§ 11. We come now to the fourth part of the theory, the monopolization of the mines. It will have been observed that there is a perpetual increase in the amount of capital needed for the economical operation of the mines. This is brought about in two ways: First, each mine requires better and more expensive plant; and second, the number of mines grows larger by reason of discoveries and the opening up of new ranges. The capital demand is the product of two factors, the amount necessary to work each mine, and the number of mines; both factors have grown throughout the entire history of the region. Such growth evidently works to delay the process of concentration, both by making it more expensive to monopolize any part of the field and by increasing the area of the field to be monopolized.

At first the individual company had only capital enough to work a mine or two. Unless the financial strength of the operating companies had grown faster than the capital requirement of the individual mine, no concentration would have occurred. On the contrary, as new discoveries were made, the control of the field would have become more and more decentralized, because other companies would have had to be formed to work the new mines, the resources of the old ones being sufficient only to operate their own prop-

erties. Accordingly, though the capital investment of each company would have risen continually, no concern could have extended its sphere of action beyond one or two mines.

As a matter of fact, the development followed a far different course. The amount of money at the disposal of successful mining corporations grew much more rapidly than that needed to work a single mine, and the surplus was spent in buying and equipping new mines, the periodic fall of prices and the resulting embarrassment of poorer companies, as heretofore suggested, giving the strong concerns especially favorable opportunities to buy valuable properties cheap.

§ 12. During the so-called period of preparation, or of moderate capital, notwithstanding the growth in size and financial strength of the companies, there was no special lessening of their number. This was due to a remarkable enlargement in the total number of the mines by the discovery of four new ranges. The change that occurred during these years was a growth in the wealth of individual companies which far outran the enlargement in the amount of capital needed to work a single mine, but did little more than keep pace with the growth in the sum required to exploit the whole district.

The last period witnesses an entire change in the situation. By the transformation of profits into capital, by the rapid growth of corporate activity, which makes the savings of all sorts and conditions of men available for investment in mining, by alliance with railroads and steamship companies, with iron makers, with steel manufacturers and machine builders, by the employment of the community of interest plan, by the use of every device known to modern finance, the capital at command of the great companies piles up at an unprecedented rate; and its increase, notwithstanding the marvelous improvements in methods and machinery

that have marked the past decade, far outruns the astonishing growth in the total amount of money employed in the industry.

§ 13. The result of this process is a division of the region among a constantly narrowing number of huge concerns. Three corporations could probably, by a combination of their resources, manage the whole ore business to-day. Tomorrow one may be equal to the task. Never, perhaps, has the world seen so unexampled a store of natural wealth monopolized with such rapidity and certainty. The one thing that enables these gigantic corporations to press forward so rapidly on the path of monopolization is their ability to bring down ore at a price which the small producer cannot reach. The enormous capital of the industrial giants, which enables them to supply their mines with the most modern equipment; to build steamships, even to construct railroads; to work mines of many sorts, furnishing every quality of ore; to save the unmarketable grades against the day when improved furnace practice and the exhaustion of the richer deposits shall have given them value; to carry on business with a view not simply to the profits of the next year, or the next decade, but to the returns of a period covering the entire life of these matchless deposits—the possession of such capital and its use under direction of the best brains whose services money can command, give the giant concerns a position of superiority from which nothing short of a social earthquake can dislodge them.

§ 14. The present division of the field among these few powerful corporations might conceivably have any one of four results:

First, fierce competition might ensue; this would inevitably cause prices to fall to a ruinous figure. The war would end with the wearing out or tiring out of the weaker among

the Titans and their capitulation to more powerful adversaries. Such a result would mean the carrying of concentration but one step nearer to its logical conclusion, monopoly.

Second, there might occur intermittent periods of competition varied by price agreements, pools, and other like devices, all having for their object the sustaining of price and not the reduction of cost. Such arrangements are essentially unstable and can do no more than delay temporarily the concentration which will inevitably proceed with the further growth in the capital of the largest companies.

Third, a community of interests might be achieved so close as to amount to virtual amalgamation. Under these conditions, though the form of independence might be preserved, its substance—competition—would be destroyed, and the monopoly which is now only apprehended would be actually realized.

It is the fourth possibility, however, which offers the most interesting problems for the future; and which is, perhaps, most likely to be realized. This possibility is the elimination of the independent producer and the eventual partition of the entire region among half a dozen great steel companies which would supply their own furnaces and those of a few favored customers, but would sell no ore in the open market.

One thing would seem to be certain,—integration has sounded the doom of independent ore production. While the great independent companies which constitute so prominent a feature of the present situation may continue work for a long time, yet so marked are the advantages of a complete industrial machine as opposed to one made up of fragmentary and disjointed parts, that when the final trial comes, as come it must some day, the independents will have to yield to the superior organization of their rivals. It

is not maintained that they will give up their corporate existence, but that they will cease to stand alone. Nominal independence may remain, but practical union there will be, if not by actual purchase, then by lease, by long-term contract, by community of interest, or by some other arrangement.

As for a possible new competitor, even though he had abundant capital, his way would be blocked. Should he be so fortunate as to discover a valuable new mine, he would still be unable to compete on even terms, for his rivals control the transportation lines, and the ownership of a mine or two would not warrant him in building a railroad and a fleet of steamers. Yet these have become essential to the most economical operation of Lake Superior iron properties to-day. What then could the independent do? Nothing except sell out to the steel companies to whom his mine would be more valuable than it could possibly be to him under the circumstances.

This supposition exaggerates the control now exercised by the steel companies and the degree of integration thus far attained, but it should be remembered that we are considering the possibilities of the present situation, and it is believed that in view of existing facts and tendencies we may look forward with confidence to the ultimate disappearance of the independent producer.

§ 15. The result of this would be the partition of the field among the steel companies; and the progress of concentration might for a time be stayed. But in such a case final monopoly under one hand,—the outcome of all the other suggested possibilities,—would have been avoided only by removing the mines entirely from the sphere of competition, or rather, by shifting competition forward from ore and pig iron to finished iron and steel goods.

Assuming such a division of the Lake Superior region,

the ensuing struggle among the steel companies would present features of the greatest interest. If the contestants were otherwise equally matched (and there is a constant tendency to equality of equipment throughout the various establishments in every modern industry), the possession of mines might well be of determining importance in the competition; and as among concerns dependent primarily on Lake Superior ores, the victory might rest with the one which had most strongly entrenched itself in that region. Any company which did not have sufficiently large holdings to warrant it in establishing rail connections with the lake if necessary, would be at the mercy of its rivals who happened to control the transportation agencies, and who could therefore raise its ore to a prohibitive cost by the simple expedient of raising rates.

The whole array of interesting possibilities suggested by considerations of this sort, as well as the other important problems raised by the growing competition of the south and the development of the open-hearth and basic Bessemer processes, are not discussed in this essay, which seeks simply to trace the operation of those laws whose working steadily lessens the number of proprietor companies in the greatest of all iron regions.

CHAPTER II

THE NATURAL CONDITIONS OF CONCENTRATION

§ 1. The greatest iron-ore district in the world lies along the shores of Lake Superior. From the five ranges of this district there have been shipped during the last five years an average of more than 22,000,000 tons a year, of which all but about 500,000 tons yearly have gone down by water. About one-sixth of this magnificent output is taken by the furnaces of the Chicago and Milwaukee district. All the rest is distributed from the Lake Erie ports, Cleveland, Ashtabula, Conneaut and Buffalo being the most important centers, in the order named.

The ore comes out by way of five shipping ports. In 1902, the year of greatest output, Duluth-Superior handled 9,700,000 tons; Two Harbors, 5,600,000; Ashland, 3,500,000; Marquette, 2,600,000; and Escanaba, the only shipping point on Lake Michigan, 5,400,000. Escanaba, distant 548 miles from Cleveland and 277 from Chicago, handles practically the whole output of the Menominee range, a considerable part of the Marquette product, and a little of the Gogebic. It has the advantage of the shortest lake haul and the longest shipping season of any of the ports, and of late years has enjoyed the benefits of a rate \$0.10 below that from Marquette and \$0.15 lower than the figure from ports at the head of Lake Superior. On the other hand, it suffers the disadvantage of a long rail haul, all of its ore coming at least 43 miles from the mines, while

some of it comes as much as 70 miles and its Gogebic shipments 90. Marquette, 598 miles from Cleveland and 573 from Chicago, ships the greater part of the Marquette ore; and Ashland, 90 miles farther up the lake, cares for almost the entire Gogebic output. The rail haul to Marquette varies from 12 miles to 36, and that to Ashland averages about 45 miles. Duluth and Two Harbors, at distances from Cleveland of 834 and 810 miles respectively, divide the output of the Mesabi range, while Two Harbors handles the whole product of the Vermilion. The Vermilion ore travels about 80 miles to Two Harbors, while the Mesabi haul is from 58 to 70 miles to Two Harbors and from 78 to 106 to Duluth. As previously stated, Marquette gets a better lake rate by \$0.05 than do these other ports. The distance to Ashtabula is 42 miles greater than to Cleveland; that to Conneaut, 55; to Buffalo, 150. Notwithstanding these greater distances, the same rate is made to all lower lake ports.

The Lake Superior iron "ranges" are so called because the ores are, without exception, found along ranges of hills or low mountains which run in general a little north of east, roughly paralleling the lake shore. Only the five ranges in the United States are considered in this essay; the developments on the Canadian side have thus far been disappointing, and while it is never safe to hazard definite predictions as to what the future may bring forth in the way of discoveries, yet the smallness of Canadian shipments up to the present time with the apparent improbability of any great increase in the immediate future is thought to warrant the omission of any detailed consideration of this part of the problem. Should important discoveries be made on either side of the border they would only delay by so much the working out of those results which are already beginning to become so prominent. We turn, then, to dis-

cuss briefly the origin and character of the five great ore deposits, making free use of the admirable publications on the subject of the U. S. Geological Survey¹ and of the state surveys.²

§ 2. The Lake Superior ores are oxides deposited by underground water action. They occur, generally speaking, in the lower levels of certain rocks, notably cherty iron carbonates, which contain a large amount of iron, and which are called the iron-bearing formations. These formations, from which the iron for the ores was derived, rest upon relatively impervious rocks such as slates and quartzites, and it is in great pitching troughs, which were formed in the process of folding and tilting these impervious rocks, that

¹For a summary of the results and conclusions of the U. S. Survey see Van Hise, *The Ore Deposits of the Lake Superior Region*, in the 21st annual *Report of the U. S. Geol. Sur.*, pt. 3, pp. 305-434. For a detailed discussion see the following monographs of the Geological Survey:

No. 19. Irving and Van Hise, *The Penokee Iron Bearing Series of Michigan and Wisconsin* (Washington, 1892).

No. 28. Van Hise and Bayley, *The Marquette Iron Bearing District of Michigan* (Washington, 1897).

No. 36. Clements and Smyth, *The Crystal Falls Iron Bearing District of Michigan* (Washington, 1897).

No. 43. Leith, *The Mesabi Iron Bearing District of Minnesota* (Washington, 1903).

No. 45. Clements, *The Vermilion Iron Bearing District of Minnesota* (Washington, 1903).

No. 46. Bayley, *The Menominee Iron Bearing District of Michigan* (Washington, 1904).

²See especially Winchell, *The Iron Ores of Minnesota*, Bulletin no. 6 of the *Geological and Natural History Survey of Minnesota* (Minneapolis, 1891), and H. V. Winchell, *The Mesabi Iron Range*, in the 20th Ann. Rep. of the *Minnesota Geological and Natural History Survey* (Minneapolis, 1893); Spurr, *The Iron Bearing Rocks of the Mesabi Range*, Bulletin No. 10 (Minneapolis, 1894); Final Report of the *Geological and Natural History Survey of Minnesota*, Geology of Minnesota (St. Paul, 1899), vol. iv, chap. xxxii.

the great masses of ore occur. Where the troughs are large and continuous, the ore bodies are generally large; where small, irregular, or broken, the deposits are usually small.

The secret of this is in the fact that ores produced by underground waters are commonly found where there have been trunk channels of circulation, and these troughs serve as such channels. In rock folding the various layers slip more or less upon one another. Thus the contact planes are places of especial weakness, favorable to water circulation. Water percolates down through the iron-bearing rocks until it strikes the impervious formation below and runs along the contact plane into the main channel formed by the apex of the trough. In this channel it flows until in some way it makes its escape at a lower level. The ores, which in general were formed by descending waters, are therefore usually found under relatively high ground, because at such points the waters were descending, while in the valleys below they were ascending and escaping. The importance of rock faulting in affording an avenue of escape is apparent.

Now such troughs as those described, because of their pitch, reached the surface of the ground at their upper end. Therefore the water flowing in them was in part, at least, meteoric water, which as it falls to the ground is heavily charged with oxygen. Going directly from the surface into the trunk channels, without percolating through any rocks, it suffered little chemical change. On the other hand, water that reached the channels only after percolating through the overlying rocks, was much changed. The iron carbonate rocks at this time were at the surface. Meteoric water, falling on them, worked its way down through, its oxygen being abstracted, and carbon dioxide liberated to join the oxygenated waters. Such carbonated waters can take into solution considerable iron carbonate and some iron silicate. Large quantities of these solutions were converged on the

sides and bottom of the trunk channels of underground circulation, where they met the other waters that had come directly from the surface and were consequently still charged with oxygen. This mingling resulted in the deposition of iron oxide, and thus the great ore deposits were laid down. If now, after such deposition, the rocks were further uplifted, so as to bring the ores nearer the surface, they would simply migrate downward, increasing in richness as they went; and there is no doubt that such migration has actually taken place. It is equally apparent that the theoretical limit of depth of the ores is simply the depth to which descending waters can pass.

The precipitation of iron oxide led to the further liberation of carbon dioxide and the taking into solution by the waters of alkalies from the basic igneous rocks over which they flowed. These solutions largely dissolved the silica from the ores, leaving them proportionately richer and more porous, and making the conditions more favorable for abundant circulation. Such abstraction of silica may have continued long after the deposition of iron had ceased, and in this manner the ore may constantly have grown richer. In the same way the phosphorus compounds may have been taken out. In general, the porous ores are low in phosphorus and the dense, impervious ones high, as would be expected, owing to the freer circulation of water in the former. On the Gogebic range, for example, the very hard, impervious ores adjacent to the dikes are high in phosphorus.

§ 3. If the chemical process of ore formation was as above described, it could take place only where there existed an impervious pitching-trough for the conveyance of oxygen-charged waters more or less directly from the face. As a matter of fact, "every iron-ore deposit of first magnitude in the Lake Superior region of the United

States rests upon an impervious pitching-trough." How were such troughs formed? In two ways. The first was the simple process of rock-folding mentioned above. The main folds on all the ranges run approximately north 70° east. Secondary folds run about at right angles to these main ones, and there are other plications of the third and higher orders. Broadly speaking, the secondary folds serve as troughs for many of the largest deposits.

The second method of trough formation was this: While the iron-bearing member and the underlying impervious rocks lay in a horizontal position, or after they were tilted, dikes of igneous rock were thrust up through them, sometimes at right angles to the bedding, sometimes at other angles. When the rocks were further folded or tilted, V-shaped troughs were formed by the basement rocks and the dikes. As the strike of the dikes differed from that of the basement rocks, such troughs pitched in one direction or the other with various degrees of steepness.

According to Van Hise, the iron of the iron-bearing rocks was largely derived from the ancient basic volcanic rocks of the region. Lying near the ocean, they were leached by underground waters and the iron transported to the seas. There, by processes of chemical and organic sedimentation, at three different periods, the iron-bearing formations were laid down. Hence there are three distinct horizons of iron-bearing rock; but only on the Marquette range are all three found, and in no other district are there important ore bodies at more than one horizon. "Within these formations, or adjacent to them, exploration is warranted. Beyond their confines exploration for ores is a useless expenditure."¹

There were six chief periods in the history of the ores:

¹ *U. S. Geol. Sur. Rep.* 21, pt. 3, p. 322.

During the pre-Cambrian period of mountain-making the iron-bearing member was elevated above the sea, folded and eroded. Being at the surface of the ground, it was exposed to the action of meteoric water, and the ores were probably fully developed.

The formations subsided and the paleozoic sea passed over them, burying them deeply under sedimentary rocks. During this time no important change took place in the ores.

The formations were again uplifted and the paleozoic rocks eroded. When erosion had cut through to the iron-bearing member, the conditions of the first period were repeated, and ore formation went steadily forward, with a constant downward migration and enrichment of the deposits.

During Cretaceous time the region was almost base-leveled, overflowed by the sea, and locally covered with rocks.

Then came the post-Cretaceous uplift and erosion, with renewed deposition, downward migration and enrichment of ores. During this time the main features of Lake Superior topography were produced.

Lastly came the pleistocene glacial action. First, glacial erosion removed vast quantities of rock and ore; if it had cut a hundred and fifty feet deeper on the Mesabi there would have been little ore left. Concerning Canadian possibilities, it is to be noted that glacial erosion on the northern side of the international boundary was more vigorous than on the southern, and in so far the probabilities are that a larger part of the deposits was lost.

Secondly, the ore bodies truncated by the glaciers were covered with glacial drift. This is best seen on the Mesabi, where large areas of the ore deposits lie directly underneath the drift. On the other ranges, where the ore bodies do not lie so flat, the relation is not so clearly seen.

§ 4. We turn now to a brief consideration of the distinctive features of each range. The Gogebic, as the simplest, is described first. While the iron-bearing rocks lay in a horizontal position, numerous impervious dikes were thrust through the underlying slates and quartzites and the iron-bearing member itself, in a general east-west direction. Then the whole formation was tilted to the north at angles of from 55° to 70° , thus causing the dikes to form the northern arm and bottom, and the underlying quartzite or slate the southern arm, of a series of great parallel troughs, most of which have a gentle pitch to the east. Where there were several parallel dikes close together, the tilting placed them one above another, and in such cases there are several ore bodies at different depths, as in the case of the Ashland and Norrie mines. The ores, then, uniformly occur in troughs formed where the dikes cut the quartz-slate member. The bodies are thickest at the bottom of the trough, and may thin out along each arm, giving the north and south "veins" sometimes found.

Roughly speaking, the Marquette district is a great trough running about east and west. Within this trough a complex series of secondary cross-folds, generally not very sharp, renders the distribution of iron-bearing formations, and consequently of ores, very irregular. A cross arch in the eastern part gives a general westward pitch to the most productive part of the formation. Intrusive igneous rocks (dikes) are very abundant. The deposits were formed in troughs composed either of impervious greenstone or slate, or of these rocks as one arm and the intrusives as the other. The complexity of the folding partly accounts for the continued discovery of new deposits, long after the exhaustion of the range was expected.

The Menominee district is likewise a complex cross-folded trough, with both the longitudinal and the cross-folds

very sharp, the dip of the former ordinarily being from 60° to 90° and sometimes overturned. The pitching-troughs consequently are very steep, running up to 70° and even 80° , so that only a small part of the deposits reaches the surface of the rocks. The district, moreover, is thickly covered with glacial drift.

The Vermilion shows the sharpest and most complex folding of any of the ranges. It is a great trough bounded on the north by granite formations and on the south by plutonic igneous rocks. The cross-folds, complex enough themselves, are much complicated by a variety of intrusives, and in connection with the folding and intrusion profound metamorphism has occurred. As a result of all these conditions, only a few large ore bodies have been discovered.

The Mesabi range differs widely in structure from the others, and it is the structural difference that gives it its great economic importance. The principles governing the deposition of the ores, however, are exactly the same as on the other ranges. The two chief differences in structure are, first, an entire absence of dikes in the district, igneous intrusives playing no part in the formation of troughs; and second, the very gentle pitch of the troughs, exposing a large amount of ore at the rock surface and making possible the open-pit method of mining on a large scale. The range is a gentle monocline, dipping to the southward in general not more than 10° . On this main fold are superimposed a series of gentle cross-folds, giving broad, shallow troughs in which the ore is laid down. The deposits pitch away from the high land to the north of them, and sometimes there is a difference of as much as a hundred feet in the two ends of a deposit. As the deposits lie so near the surface, glacial erosion resulted in very considerable losses of ore, and at the recession of the glaciers, the drift was left lying directly on top of the ores. The thick-

ness of the drift varies widely, from nothing to a hundred feet.¹

§ 5. From this sketch of the method of ore deposition it will be understood that the ore occurs in veins and lenses and pockets. The deposits are of varying size and irregular shape, so that the quantity of ore in any particular mine cannot be foretold with any degree of certainty, although the general extent of the various ranges has been made out fairly well.

The mines of the Marquette, the oldest and most thoroughly explored range, extend from Palmer, Negaunee and Ishpeming about 25 miles west to Michigamme and Spurr, near the western end of Michigamme Lake, with a tongue running south 10 miles from Champion to Republic. The easternmost mines are some dozen miles from Marquette, and the most distant have a haul of 36 miles. This iron belt is from three to ten miles wide. The Duluth, South Shore & Atlantic, a branch of the Canadian Pacific, and the Lake Superior and Ishpeming, a little road only twenty miles long, carry its ore to Marquette, while the Peninsular branch of the Chicago & Northwestern gives it an outlet by way of Escanaba, and the Chicago, Milwaukee & St. Paul takes some ore all-rail to Milwaukee. Marquette ores are of many varieties. The hard specular ore of the Republic mine was for years the standard for high-priced Bessemer ores, and Marquette magnetic ores were only less favorably known. The soft red hematites of the district have been scarcely less important.

The Menominee range, under which we include also the Crystal Falls district of the geologists, covers the largest territory of any range except the Mesabi. It extends from

¹It is needless to say that in this account of the geology of the ores I have followed closely the masterly discussion of President Van Hise, in many cases making use of almost his exact language.

Waucedah, about forty miles west of Escanaba, on both sides of the Menominee River west and north to Iron River and Stambaugh, a distance of some 50 miles. Its ore goes out over the Northwestern to Escanaba, a haul of from 43 to 72 miles. The Milwaukee also taps the district. Many of the Menominee ores are high in phosphorus, and the low iron content of some of them, even those which are low in phosphorus, has prevented their finding a market in dull seasons. Since the discovery of the Mesabi, however, the demand for high silica ores has greatly increased, and as the Menominee can furnish these ores in abundance, its importance is increasing.

The Gogebic range, remarkable alike for the simplicity of its structure and the richness of its ores, extends from Gogebic Lake, east of Bessemer, Mich., for about thirty miles west. The iron-bearing formations are over a large part of its length very narrow. The Gogebic ships chiefly over the Northwestern and the Wisconsin Central to Ashland, the length of the haul varying from 39 to 59 miles. A little ore is shipped by way of Escanaba, a haul of almost 90 miles. The ore of this district is a soft, red, somewhat hydrated hematite, largely of Bessemer quality, and so friable that it can be broken with a pick. Much of it is manganeseiferous.

Turning now to the Minnesota ranges, we find the Vermilion a small district extending about 25 miles from Tower to Ely. It lies 80 miles directly north of Duluth, through a swampy, thickly-wooded country, difficult in the extreme to traverse. The Duluth & Iron Range railroad hauls all of its ore from 68 to 87 miles to Two Harbors. The ores of this range comprise several varieties, but the predominant one is an exceedingly hard, massive, granular, steel-blue hematite, which has to be blasted with dynamite and then run through a crusher. The ore from the famous

Chandler mine is called a soft ore only because it occurs in a finely-brecciated condition. These Vermilion ores are of both Bessemer and non-Bessemer grades, and are much sought after by furnacemen to mix with softer, finer-grained ores.

The Mesabi range, latest discovered and most productive of all, extends from Grand Rapids, on the Mississippi River, in a direction east-northeast about 100 miles to Birch Lake, with a width varying from 2 to 10 miles. Its area is about 400 square miles. Practically all of the mines are between Mahoning and Mesaba Station, not more than 40 miles apart. The main topographical feature of the district is a ridge known as the "Giants" or Mesabi range, which rises about 500 feet above the level of the surrounding country. It is on the southern slope of this range that the ore deposits lie in shallow, irregular basins, usually with greater horizontal than vertical dimensions. Their horizontal dimensions vary from a few feet to almost two miles, and commonly show considerable extension in one direction. The width seldom exceeds a quarter of a mile; the length is not uncommonly half a mile or more. The thickness runs up to 350 feet, though most of the deposits are not over 200 feet deep and some are being mined which do not extend downward more than 60 feet. These great ore beds, it must be remembered, lie right at the rock surface and are covered only with a varying thickness of glacial drift, running from nothing up to 100 feet. The ores, which are mostly hematites of all varieties and textures, are generally so soft that they can be scooped out by steam-shovel with little blasting. They are usually so fine that not more than 50 per cent of Mesabi ore is used in making a furnace mixture. A good proportion of them, perhaps from a half to two-thirds, is of Bessemer grade. It is the shallowness of the deposits and the softness of the ores which have made

the Mesabi mines indeed the "Giants" among the world's producers. More than two-thirds of the Mesabi ore is transported a distance of 71 to 106 miles to Duluth and Superior, while the rest of it goes to Two Harbors, a distance of from 58 to 70 miles. The two Steel Corporation roads, the Duluth, Missabe & Northern and the Duluth & Iron Range, and Mr. Hill's Eastern Minnesota, connect the mines with Duluth and Superior, while the Duluth & Iron Range furnishes the only outlet to Two Harbors.

§ 6. How much ore is there on these five great ranges? No one knows, though many guesses have been made. What we do know is that the production of these mines during the past fifty years has shown a growth unequalled in the world's history. Up to 1859, 150,000 tons were shipped; from 1860 to 1869 the output was 3,000,000 tons; during the next ten years 10,000,000 tons came down the lakes; the years from 1880 to 1889 showed a product of 35,000,000 tons; during the last decade of the nineteenth century the production was 104,000,000 tons; while the five years from 1900 to 1904 showed the astounding total of 113,000,000 tons. During these last five years the great Superior ranges have sent down the lakes twice as much ore as they produced up to and including 1890, while the output for the single year 1902 was equal to the entire shipments of the region from 1854 to 1885 inclusive. The iron men expect that 1905 will surpass the record of 1902. How long the Lake Superior mines will be able to keep up their present astonishing rate of production is a problem no less interesting than important. Of late years they have produced more than 70 per cent of our iron ore, while, on account of their superior richness, we must give them credit for four-fifths of the total if we take account of iron content. The present dependence of the American iron industry on these ores is evident enough, and with more than

260,000,000 tons already shipped out, it is a matter of vital interest to the American ironmaster how much ore remains in these vast deposits.

§ 7. It is to be remembered that all estimates must be received with the greatest caution, even when made by the most competent students with full knowledge of the facts. In an address delivered in 1886 before the American Institute of Mining Engineers, Mr. John Birkinbine, who speaks with authority on such matters, said:

In the Marquette district no large mine has been discovered since the Republic was opened in 1872, although explorations have been constantly active in that district. The larger producers have a considerable amount of ore in sight, but each year apparently depletes them more and more. Lenses fail and others come in, but the workings are constantly growing deeper and more uncertain, and the difficulties and expenses of getting the ore increase correspondingly. In the Menominee district most of the great producers are able to maintain their positions, but this range and the Marquette range will hardly exceed their maximum output of 1882.¹

The output of the Marquette in 1882 was 1,900,000 tons; that of the Menominee, 1,000,000; and the facts appeared to justify Mr. Birkinbine's rather pessimistic view of the future of these ranges. Yet there has been but one year since 1888 that the Marquette has failed to pass the two-million mark, and from 1899 to 1903 it averaged almost 3,500,000 tons a year, while the Menominee reached an average almost a quarter of a million better and in 1902 shipped 4,600,000 tons. Thus dangerous is prophecy in the Lake Superior region, even when based on careful study.

¹ *Transactions American Institute of Mining Engineers*, vol. xvi, p. 177.

In 1894, Mr. J. Parke Channing stated that there was thought to be not more than 15,000,000 tons of Bessemer ore left on the Gogebic.¹ Since that time there have come down from that range nearly 30,000,000 tons, largely of Bessemer grade.

With so much by way of caution, it may not be without interest to quote one or two of the most recent competent estimates. We may disregard such fantastic calculations as those of a recent distinguished British visitor, who was led, quite possibly by information given by interested parties, to express the belief that the whole Mesabi field will have a life of approximately but twenty-five years. Mr. C. K. Leith says:

An examination of the general map of the Mesabi district shows that there are many iron-ore deposits on the range which have not yet shipped ore. This is because of their grade or because they are controlled by companies which have enough ore for present shipments in properties already opened up. By leaving the ores untouched, taxes and the interest on the large investment necessary to open up a mine are saved. Other mines have been opened up and but small shipments made because more desirable ores or more cheaply mined ores were controlled by the same company in other mines. With the mines already opened up, including the steam-shovel mines, the annual production of the district could be enormously increased without opening any more deposits.

The tonnage of individual properties ranges from a few thousand tons up to a possible maximum of 70,000,000 tons. Several deposits are known to have between 20,000,000 and 40,000,000 tons of ore. The total amount of ore of present marketable grade—that is, containing above, perhaps, 58 or 59 per cent of metallic iron—at present (1902) in sight on the Mesabi range has been estimated at 500,000,000 to 700,000,000

¹ *The Mineral Industry for 1894*, p. 380.

tons. Six hundred millions is a commonly accepted figure. Of this, with proper mixing, perhaps 60 to 70 per cent is Bessemer ore. These figures are necessarily based on incomplete data, but they are commonly accepted by those best qualified to judge. Ore running below 58 or 59 per cent in metallic iron is known to be present in enormous quantity, but the amount has not been estimated nor are the data for an estimate likely to be available for some time to come. Within recent years steps have been taken to reserve the best of it. Ores running as low as 50 per cent, while not exploited, are being put aside by the large companies for future use. At the mines where it has been found necessary to move low-grade ore in order to get at the high-grade ores, the low-grade ores are in some cases being stock-piled where this can be done at small cost.

The aggregate amount of high-grade ore in sight up to 1902 on all the "old ranges" of the Lake Superior region has been thought not greatly to exceed 350,000,000 tons. Even if the estimates for the Mesabi range and the old ranges are considerably away from the truth, it is certain that the Mesabi holds a commanding position in the region in its reserve tonnage. When it is remembered that even before the discovery of the Mesabi ores the Lake Superior region was regarded as the richest iron-ore-bearing region in the world, it is apparent that the Mesabi district has no peer.¹

The *Wall Street Journal* has recently estimated the Hill holdings on the Mesabi, which rank next in importance to those of the Steel Corporation, at 500,000,000 tons. Other estimates of the same properties place the amount at all the way from 300,000,000 to 800,000,000 tons. It will be remembered that Mr. Schwab, testifying before the Industrial Commission in 1901, put the total ore holdings of the corporation at not less than half a billion tons.² If the corporation holds more ore on the Mesabi

¹ Monograph no. 43 of the *U. S. Geol. Survey*, p. 290.

² *Report of the Industrial Commission*, vol. xiii, p. 464.

than does Mr. Hill, it will be seen how incongruous are the various estimates made even by those who are best informed, and it will be conceded that as a matter of fact no one really knows how much ore lies hidden in the depths of this wonderful Lake Superior region. H. V. Winchell has made the interesting suggestion of the

possibility that the ores of the Mesabi will be found to extend indefinitely to the south under the black slates of the Animikie, and even under the gabbro and trap rocks of the Lake Superior basin until it appears in the Penokee-Gogebic range on the south shore. In that case the supply of iron which may be counted on for future production is simply incomprehensible and inexhaustible. The greatest and deepest mines of the world will be developed here, and the industry of iron mining and manufacture in this state will continue to grow until iron is no more an article of consumption.¹

While admitting this as a possibility, however, Winchell very properly regarded such a development as improbable, and thought that the merchantable ore-beds would prove to be narrow and local in extent.

In view of the facts and estimates heretofore adduced, I cannot do better than to close this interesting branch of the discussion with the judicial words of Mr. D. H. Bacon, who in 1897 said:

With the low prices that are here to remain, it is ever more difficult to estimate the annual consumption. Speaking of the several ranges as one, the acreage of known ore is but a small part of the area that may contain ore. Discoveries are still being made in the Marquette district, the exhaustion of which was expected twenty years ago. And I may say in

¹ Winchell, 20th Annual Report of the *Geological and Natural History Survey of Minnesota* (Minneapolis, 1893), p. 117.

passing that the known ore under the bed of Lake Angeline is four times as great as was all the known ore in all the mines of that county at any time prior to 1887 For forty years this region has met all the demands; its resources are to-day as compared with the demand greater than at any time in the past; and I believe that those who are now active will have stepped aside and will perhaps have been forgotten before this region will fail as an adequate source of supply.¹

§ 8. Regarding the possible exhaustion of the deposits, it should be remembered that exhaustion is a term almost purely relative. The limit of depth on the Mesabi can, indeed, be pretty definitely determined, and even on the older ranges the geological survey maintains that little ore is likely to be gained below the thousand-foot level. Some practical mining men, however, disagree with this opinion, and a number of the mines are already working profitably far below the depth stated. Exhaustion means practically, for any period we can now see, nothing more than a progressive increase of cost and a progressive recourse to leaner and more phosphoric ores. In the early days no ore carrying less than 65 per cent of iron was marketable, that is, could be sold at a profit. Ten years ago the Mesabi ore that did not furnish 60 per cent of pure iron was thrown on the dump-heap. To-day Mesabi ores running down to 55 per cent of iron are being shipped at a profit, while some old-range, high-silica Bessemer ores carrying no more than 40 per cent of iron are going down the lakes. It is not only the exhaustion of the best deposits that has brought about this result, but also better methods of sorting the ore, and better handling at the furnace. None the less, the law of diminishing returns is steadily at work in the Lake Superior region, and in the absence of new discoveries we must face a

¹ *Transactions Amer. Institute Mining Engineers*, vol. xxvii, p. 344

condition of leaner ores and increased cost of production, so far as it is not offset by larger capital expenditure.

The growth of the open-hearth steel process, moreover, may have important results for the region. For thirty years Bessemer ores have commanded from \$0.50 to \$2 more than non-Bessemer. The suitability of ores for the Bessemer process of course depends primarily upon the proportion of phosphorus; ores which contain more than one part of phosphorus to a thousand of iron, or in the case of the ores we have used thus far, more than about .055 per cent to .06 per cent of phosphorus, are unavailable. The Lake Superior mines have perhaps the largest deposits of pure Bessemer ore in the world, and it is this fact that has given them their present primacy. Evidently the change to open-hearth steel-making and the basic Bessemer process, by making available more phosphoric ores, may bring Lake Superior much more sharply than ever before into competition with southern, eastern and imported ores. Such a competition, by making impossible a rise in the price of Superior ores as the mines are exhausted, would make only more imperative the application of capital to keep down cost, and so would but give more point to the theory presented in the first chapter. The whole question of the possible effects of the changes of process now taking place in steel manufacture is too large for consideration in a monograph of this character, and is therefore omitted.

§ 9. To summarize briefly, the five great iron ranges lie almost parallel to the lake shore and distant from their shipping ports from 12 to 90 miles, the prevailing grades on the railroads being favorable to the loaded trains. The nearest of these shipping ports is about 550 miles by lake from Cleveland, the center of distribution to the furnaces, and the most distant of them about 300 miles farther away.

The ores, deposited by underground water action in great

pitching troughs, occur in masses of varying size and irregular shape. The Mesabi deposits differ from all others in that they lie in flat, shallow troughs near the surface. They are, moreover, more friable than any of the old range ores, the Gogebic most nearly approaching them in this respect. Ores of every degree of hardness, varying widely as to phosphorus, silica and moisture contents, and suitable for the most various processes of iron and steel-making, are to be found on the different ranges. The mines are most widely celebrated for their production of Bessemer ore.

CHAPTER III

THE PERIOD OF EXPLOITATION

§ 1. The copper deposits of Lake Superior were known from the early seventeenth century, but it was not until September, 1844, that a party of government surveyors made the first discovery of iron about a dozen miles west of what is now Marquette. On July 23, 1845, a mining association was organized at Jackson, Michigan, and shortly afterward a party of its explorers, under Indian guides, found, near the place of the previous discovery, "a mountain of solid iron ore, 150 feet high." Three hundred pounds of ore was carried out on men's backs the next year, and taken to Jackson, where it was made into a bar of iron in a blacksmith's forge. Early in 1848 the company completed a forge on the Carp River near the mine. Three six-horse teams were required to draw the product of about three tons of iron a day to the mouth of the river over ten miles of execrable road. It was next to impossible to get the iron to the lake, or to get supplies to the men, and charcoal and ore to the forge. The water power proved insufficient and the forge steadily lost money.

In June, 1848, the original Jackson Association was merged into an incorporated company, the Jackson Mining Company, with an authorized capital stock of \$300,000 in shares of \$100 each. Only a small amount was paid up. In 1849 the charter was amended and the name changed to the Jackson Iron Company.

By the latter part of that year the company was in trouble.

Its credit was at low ebb, its agent had left, and the men at the works talked seriously of hanging and quartering the president, who wisely followed the lead of the agent and departed. In the spring of 1850 the company, as a local writer says, "bust" all up, and all work at the mine and forge was suspended. In the fall new managers arrived with a large quantity of supplies. In less than a year they failed, and their men did not get a dollar in money.

Meantime the proprietors of iron works in western Pennsylvania were investigating. In 1850 five tons of ore were sent down to Newcastle, in that state; and in 1852, 70 tons were shipped to Sharon and smelted in a blast-furnace. General Curtis, chief owner of the Sharon Iron Company, in anticipation of the opening of the Sault Canal, determined to buy the Jackson property, consisting of 900 acres of land, a forge and twenty dwelling-houses. In September, 1851, he purchased a controlling interest in the Jackson Company, securing 1507 shares out of 3,000 at \$15 a share, amounting to \$22,605.¹ Even at this early date General Curtis believed that the proper policy for the Lake Superior mines was to sell their ores to the Ohio and Pennsylvania furnaces, instead of trying to do smelting themselves.²

The Marquette Iron Co., which was second in the field, had about the same experience as the Jackson. It built a forge with ten fires at Marquette. In 1849 it opened the Cleveland mine, and in the winter of that year had twenty or more double teams employed in hauling ore the fifteen miles from mine to forge. It was not necessary to

¹ Swank, *History of the Manufacture of Iron in All Ages* (Second edition, Phila., 1892), p. 325.

² For early history of the Jackson and other companies see *Geological Survey of Michigan*, vol. i, pt. i, *Iron Bearing Rocks (Economic)*, by T. B. Brooks (N. Y., 1875). Statements made in this chapter without other citation of authority are largely drawn from this source.

employ powder in getting out the ore, as thousands of tons had rolled down and lay in huge stock piles at the base and up the sides of the iron hills. Despite the cheap ore, the forge was a failure from the first, and in 1853 the company was glad to sell out to the Cleveland Iron Co., a new concern organized with a nominal capital of \$500,000, in shares of \$25 each. The same year the Lake Superior Iron Co. was organized with an authorized capital stock of \$300,000. These three were the only companies whose mining operations actually assumed much importance before 1864. Others were formed, two more incorporating during 1853 and two the next year, but their operations were of small importance.

Up to 1855 the lack of transportation facilities prevented any real development of the region. To quote Major Brooks, "there was no dock at Marquette, no canal at the Sault, scarcely a road in the country, no shop for repairs, no skilled labor but what was, together with all supplies, imported 'from below,' and no regular communication."¹ During the summer of 1849 only three sailing vessels and five propellers came to Marquette. The mines were fifteen miles from the lake, through an almost trackless forest. At the foot of the lake were impassable rapids. Whatever ore was shipped had to be unloaded there and hauled over the portage. The process was slow and the cost prohibitive. A railroad from mines to lake and a canal at the Sault were absolutely necessary.

§ 2. The matter of a canal had long been agitated, and Governor Mason in his message to the first legislature of Michigan, in 1837, urged its importance. The proposition was brought before Congress, where Henry Clay referred to the project as "a work beyond the remotest settlement in

¹ *Geological Survey of Michigan*, vol. i, p. 21.

the United States, if not in the moon." Nevertheless Congress in 1852 granted Michigan 750,000 acres of land to build a canal, and in 1853 a contract was made with the St. Mary's Falls Ship Canal Co., a corporation organized in New York. They agreed to finish the work within two years, and after spending \$999,802.46 were able to turn over the canal to the state, which threw it open to the public in June, 1855. The company received in payment the land granted by the general government to the state. Among the lands which it selected was the famous Calumet and Hecla quarter section, which it disposed of for \$60,000. Speaking of the canal, in his report of 1877, the Chief of Engineers of the United States says: "In view of the large amount of capital required, no return being possible until after the sale of the lands, the isolation of the locality, inaccessible during five months of the year, and the severity of the climate, which greatly retarded work during winter, the rapid construction of the canal was a remarkable feat."

The canal thus built was at the Falls of the St. Mary's River, a stream about seventy-five miles long connecting Lake Superior and Lake Huron. In the first fifteen miles the river falls about one-tenth of a foot; at the falls and rapids, which are about a mile in length, 18 feet; in the 35 miles between the falls and Mud Lake, 2.3 feet; for the 25 miles from Mud Lake to Lake Huron there is plenty of water. The canal completed in 1855 was 5,400 feet long, 100 feet wide, and had 12 feet of water at a mean stage. There were two locks, each 350 feet long and 70 feet wide, with a lift of 9 feet. They were large enough to contain a tug and three vessels of ordinary dimensions.¹

The 35 miles of the river between the falls and Mud Lake had many shallows and dangerous places, and between 1855

¹ For early history of the Sault Canal, see *Reports of the Chief of Engineers of the United States*, especially for 1877 and following years.

and 1869 Congress appropriated over \$200,000 for channel improvements.

The completion of the canal solved the second half of the transportation problem, but it was only a less serious matter to get the ore from the mines to the lake. A railroad was projected in 1852, contracts having been made with the various mining companies to haul their ore. The rates to be charged were considered too high, and therefore the Jackson and Cleveland companies in 1853 undertook the building of a plank road, on which, according to Swineford's statement, they spent most of their paid-in capital.¹ Longitudinal sleepers with strap rails were laid and horse-cars were run, carrying ore at a nominal rate of \$1 a ton. Each team made a round trip a day bringing four tons of ore. The road was used only two seasons and the \$120,000 spent on it was practically a dead loss.²

Meantime the railroad company incorporated as the Iron Mountain Railroad, ultimately becoming a part of the Marquette, Houghton & Ontonagon. It was finished from Marquette to the Lake Superior mine, a distance of about 16 miles, in 1857. The next year it carried to Marquette 30,000 net tons of ore; in 1860 its tonnage was five times as great, and in 1863 it carried down 203,797 net tons of ore and 7,021 of pig-iron, at a rate of \$1 a ton.

§ 3. The canal and railroad having thus opened up the mining region, a considerable stimulus was given to speculation in iron property, and from 1855 to 1859 eight companies were incorporated, chiefly for the purpose of making iron on the Upper Peninsula. Their nominal capital was usually from \$200,000 to \$500,000, in \$25 shares; their actual paid-up capital not the fifth part of the nominal capitalization. Only

¹ Swineford, *Mineral Resources of Lake Superior* (Marquette, 1876).

² *Michigan Geological Survey*, vol. i, p. 22.

the three oldest mines made shipments before 1864, but the other companies took out considerable ore and worked it up into iron, with the usual result of financial disaster. The crisis of '57 prevented any marked development. Pig-iron prices declined sharply, and the struggling Lake Superior companies were on the verge of bankruptcy. The Pioneer Iron Company, which in 1857 built the first blast-furnace on the lake, had to sell for \$22 iron that cost \$24 to produce. So it leased its property for four years, the lessee proving as unfortunate as the company had been. The story of the other companies during the same years differed little. All of them were more or less involved in difficulties, many of them suspended operations, some went bankrupt, others sold out or were merged with stronger companies. The increased output of the district during the next five years is accounted for wholly by the activity of the three largest companies, the Jackson, the Cleveland, and the Lake Superior.

To sum up the situation from 1855 to 1862, it may be said that transportation facilities were so far improved as to make it possible to get ore out, but that the mines had not yet been really brought into relation with the iron market. Therefore the companies met with no real success, whether they tried to make iron themselves or to send their ore down to the furnaces of Ohio and Pennsylvania. The Lehigh Valley, and not Pittsburg, was still the iron center of the United States.

The war suddenly changed the whole outlook. A great demand sprang up for all kinds of iron goods, and both mining and iron-making on the Upper Peninsula received a strong impetus. Shipments increased from 49,000 tons in 1861 to five times that amount in 1864, while the companies made fabulous profits, as would be expected when the sharp rise in price is noted. A prospectus of the Cascade Iron Company issued about this time quotes from the report of

the directors of the Cleveland Company for the year ending May 18, 1864. This report shows that the company had a capital of \$500,000, of which \$280,000 was paid up, or \$14 a share. After paying all expenses, the net profits for the year were \$201,601.85, or about \$4.15 a ton on the output of nearly 50,000 tons. From the same source we learn that the Jackson Company on May 31, 1864, had a paid-up capital stock of \$300,000. During the year it sold 73,137 tons of ore at a profit of \$411,235.91, or about \$5.60 a ton. Add to this the surplus on hand May 31, 1863, \$164,280.59, and the amount available for dividends at the close of the year, May 31, 1864, was above \$575,000.¹ Deduct quarterly cash dividends of 25 per cent, or 100 per cent per annum, and the surplus after payment of dividends was still almost equal to the capital of the company. It is not strange that from the time when the Jackson Company declared its first dividend in 1862, its stock always commanded at least five times its par value.² In July, 1863, the Morgan Iron Company was formed with a capital of \$50,000, \$26,000 paid in. It had a blast-furnace in operation by November, and ten months later had realized dividends of 100 per cent over and above its total outlay in construction.³

In view of such profits it is small wonder that company promotion again became popular. No new companies seem to have been formed during 1860, 1861 or 1862. Two new ones came into existence during 1863 and eight more appear on the records for 1864. Their capital was usually \$500,000, divided into \$25 shares, of which from \$20,000 to \$100,000 was paid in. In 1864, for the first time two other

¹ *Prospectus of the Cascade Iron Company of Lake Superior* (Philadelphia, 1865).

² Swineford, *Mineral Resources of Lake Superior* (Marquette, 1876), p. 102.

³ *Michigan Geological Survey*, vol. i, p. 35.

mines added their shipments to those of the three pioneer concerns.

§ 4. The year 1865 marked a slight retrogression, but the eight years following saw a wonderful growth, the boom in iron and steel reflecting the rapid industrial development of the country, and from 1870 to 1873 registering its speculative excitement. From 1861 to 1865 the average number of miles of railroad built was about 900. In 1866, 1,716 miles were laid down; three years later the figure rose to 4,615; in 1870 to 6,070; while in 1871 the railroad-building boom culminated with a new mileage of 7,379 miles. Our approximate rail consumption rose from 263,310 tons in 1863 to 462,630 in 1866, and to 1,366,830 in 1872. This trebling of demand in six years, combined with a duty of \$15.68 on iron rails, caused the production of our mills to more than double during the same time, rising from 385,000 tons to nearly 810,000. The manufacture of steel rails was just beginning, with a protection of 45 per cent up to January 1, 1871, and \$28 a ton thereafter. In 1867 we produced 2,200 tons; in 1872, 84,000. Despite the enormous duties, rail imports during these years rose from 78,000 to 474,000 tons. The price of iron rails, which stood at \$86.75 in 1866, gradually declined in accordance with the course of general prices to \$70.37 in 1871, only to leap back to \$85.12 in 1872. Prices of steel rails, starting at \$166 in 1867, stood at \$112 in 1872, and \$120.50 in 1873. The pig-iron product of 1866, with the average Philadelphia price of No. 1 foundry at \$46.88, was 1,205,663 tons, and the import 124,000 tons. For 1871 the price was \$35.12, and for 1872, \$48.88. Stated in terms of gold, these prices are about \$33.50, \$31.56 and \$43.75 respectively. In 1871 production and imports were 2,548,713 tons and 264,256 tons respectively, and 1873, despite the depression of the later months, surpassed these figures of production by more than

10,000 tons. The wonderful expansion of these six years is evident enough.¹

The last three years of this upward movement were especially notable. The ending of the Franco-Prussian war had set free a large amount of capital for industrial uses, and the continental market was scarcely less clamorous in its demands than the American. No. 1 pig in Wales was worth 75 to 85 s. in July, 1871, and 140 to 150 s. a year later, while No. 1 pig in the New York market rose from \$30 in January, 1871, to \$36 in January, 1872, to \$50 in March, and to \$55 by midsummer. Every effort was made to increase production. Every old furnace was repaired and put into blast, and scores of new ones were built, many of them by local companies with small capital and poor equipment; but there were also put up many large, well-equipped and well-located furnaces, which were destined to set a new standard in American iron-making. Pittsburg up to 1872 had only five blast-furnaces, making 1000 tons a week. That year four new ones went into blast, increasing the capacity by 1,700 tons.² So great was the activity of 1872 that several makers in March bought back their contracts at a bonus of \$14, the difference between the contract and the market price. With 50,000 miles of railroad projected or under construction, the only reason that but 7,613 miles were that year completed was simply inability to get the capital from abroad; our own capitalists could not yet furnish the money. The amount of iron wanted for bridges, heavy machinery, buildings and a hundred other new uses was unprecedented, and as usual in such cases, every one expected the golden times to last forever.

¹ Figures of production and prices from *American Iron and Steel Association Reports*.

² *Iron Age*, Feb. 6, 1873.

§ 5. The development of the Lake Superior mines during the ten years from 1863 to 1873 is even more wonderful than the growth of our general iron trade. In 1863 but 3 mines shipped ore; in 1864, 5; in 1865, 7; in 1866, 9; 1868 added 4 more mines; 1870, 3 more; while in 1872 the table of shipments increases the total number of mines by 11 to 29; and in 1873 no less than 40 are represented. The total shipments of 1866 were just below 300,000 tons; those of 1873 almost exactly four times that amount.¹ The first report of the Michigan Geological Survey gives the names of 11 new companies organized from 1865 to 1869 and 14 during 1870-73, to say nothing of mines worked by individuals. Feverish activity characterized the industry.

The course of prices during these years is difficult to trace. The data given by the Michigan Commissioner of Mineral Statistics in his report for 1890 (p. 56) indicate variations from a low point of \$7.50 for standard Bessemer ores in 1865 up to \$12 in 1873, the average of his figures for the years 1866-73 being \$9.25, as against \$5.85 during 1858-62, \$7.50 in 1863 and \$8.50 in 1864. It must be understood, of course, that prices for these early times are not to be too confidently relied upon, but in any case the remarkable increase in price and the consequent stimulus to production during the years mentioned appears clearly. Lake Superior red specular ores for 1872 were generally contracted at \$9 to \$9.50 f. o. b. Cleveland, terms \$3 cash and balance four months from delivery. The unlucky furnacemen who had to buy additional ore later in the season paid much higher prices, quotations reaching \$15.50 in December.² Besides setting their '73 price at \$12, the ore men required the furnace owners to receive the ore whenever it

¹ *Michigan Commissioner of Mineral Statistics*, rep. 1877-8, table.

² *Iron Age*, Dec. 21, 1872.

came and whatever its quality.¹ With such prices and conditions prevailing, the mining men fairly coined money despite the fact that the vessel owners compelled them to pay for the lake haul a rate of from \$2 to \$6.50 a ton.

One or two examples will illustrate what was occurring. The Saginaw mine, leased on \$0.50 royalty, came on the market in 1872 with 18,000 tons of ore. In the fall the lessees sold out for \$300,000. In 1870 a single hut marked the site of the Republic mine, perhaps the most wonderful deposit of the Marquette district. The railroad reached the mine in 1872, and the company opened up a vein of pure ore 3,500 feet in length, of which 2,000 feet was without a break. Like many of the other great deposits, the Republic was a small mountain of ore, and it was mined by the open-cut method from 50 to 75 feet below the outcrop and for a distance of 2,000 feet. In 1873 the product was 105,000 tons, and the next year, despite the panic, more than 122,000. An analysis of 14 samples taken during its first four years gave 68.48 per cent metallic iron and .053 per cent phosphorus.² Such ore deposits as these with such prices as those prevailing meant fortunes for the mining men, and they poured their profits back into the industry, opening new mines by the dozen.

§ 6. All this activity made necessary a large increase in transportation facilities. In December, 1864, the Chicago & Northwestern had opened its Peninsular line from Negaunee to Escanaba, a distance of 62 miles, at the same time building, at an expense of \$200,000, an ore dock with pockets having a capacity of 20,000 tons of ore, and unloading directly into vessels without shoveling. The im-

¹ *Iron Age*, Jan. 26, 1873.

² Swineford, *Mineral Resources of Lake Superior* (Marquette, 1876), pp. 168-174.

portance of this line in developing the region will be seen from the following table of shipments *via* Escanaba: ¹

<i>Year.</i>	<i>Tons.</i>	<i>Year.</i>	<i>Tons.</i>	<i>Year.</i>	<i>Tons.</i>
1865	31,072	1868	273,405	1871	447,253
1866	116,868	1869	331,660	1872	481,982
1867	196,831	1870	413,786	1873	453,416

At the opening of navigation in 1873 the Marquette, Houghton & Ontonagon had a dock capacity at Marquette of 22,600 tons, so the facilities of the two roads serving the district at this time were approximately equal. For the short haul to Marquette this road had 1,600 ore cars and 28 locomotives, while the Northwestern expected to use 3,000 cars and 33 engines between Negaunee and Escanaba. ²

The lake fleet, also, was rapidly increasing, both in number and in size of vessels. The average capacity of vessels loading at Marquette in 1872 was about 650 tons, ranging from 400 to 1,100. About one-fourth of the ore shipped was taken away by steam.

§ 7. Having sketched hastily the course of development during these twenty years, we turn now to a consideration of the methods of work employed as a result of the conditions prevailing, and the consequent status of mine ownership. The one prominent fact is the wonderful richness of the deposits and the relatively small amount of capital available for working them. The remarkable conditions prevailing at the Cleveland mine in the beginning, when no digging at all was required, will be recalled. Writing in 1866, Daddaw and Bannan say that nothing but surface, or patchwork, had at that time been done. All the ore was quarried from shallow openings in the sides of the iron hills; no pumping machinery was set up, and adits for

¹ *Mich. Commr. of Miner. Statis.*, Rep. for 1886, p. 16.

² *Michigan Geological Survey*, v. i, p. 41.

drainage had just been begun. Mining was simply a process of blasting large masses from the ledges of ore; such masses were then broken up by other blasts, by the sledgehammer, or by building on them a fire of huge logs. A single hole eighteen feet deep and two inches in diameter loaded with powder had in one case brought down 4,000 tons of ore at the Jackson mine. The ore at that mine was loaded into one-horse carts and hauled a few hundred feet to the railroad, where it was thrown into six-ton four-wheel cars and carried to Marquette to be transferred (apparently by wheelbarrow) to the vessels.¹ From another source² we learn that it was usual to work the ore deposits in open trenches, often five hundred feet long, with a breast of sixty feet. The average amount mined Foster estimates as five tons a man a day and the cost of mining, with wages at \$2.50, as \$1.25 to \$1.50 a ton. Swineford in 1870 put the cost of delivering ore on railroad cars at the mines at \$2 a ton, not including dead work. All these early estimates of cost are inexact, but it is evident that the greater part of the cost of ore on the docks at Cleveland was incurred in handling the product from the time it left the miners' hands till it reached the lower lake ports.

§ 8. Major Brooks' classical report³ discusses the whole matter of methods and costs, about 1870, with admirable clearness and completeness. He says: "No considerable amount of ore has as yet been mined underground in this region, and of that so mined very little has been taken out at a profit, and I may add that it seems to be the belief of the most experienced mining men that this state of things will hold for some time to come." The irregular shape of

¹ Daddaw and Bannan, *The Practical American Miner* (Pottsville, Pa., 1866), p. 550.

² Foster, *The Iron Ores of Lake Superior*, p. 34.

³ *Geological Survey of Michigan*, vol. i.

the deposits, necessitating constant change in the plan of underground work, their great thickness, running up to fifty feet and making timbering very difficult, and the unreliable character of the rocks composing the roof, rendering underground work dangerous, were the main reasons for this belief. Practically no underground work had been done, as much as forty feet of earth and nearly as great a depth of quartzite having in some cases been stripped to avoid the necessity.

There were three great advantages in open pit work under the circumstances then prevailing. The first was the small initial outlay required.

It would be difficult to convince our people that, having a large deposit of pure ore before them of unknown form and size, covered often by but little earth, and backed by perhaps a small amount of money in the company's treasury, it is best to incur the delay and cost incident to sinking and drifting to open ground already opened by nature and ready to win. Wrought as open quarries, several of our mines have paid their way from the start, while, had they been opened on a regular system of mining, it would have required an investment of \$50,000 in plant and improvements before shipments could have begun, and at least one year's time. Such facts settle such questions with American capitalists;—and with the uncertainties which attend the opening of new mines in new districts, the high rate of interest in this country, and uncertainty of tariff legislation regarding iron, it may be a question whether this hand-to-mouth, quick-returns, let-the-future-take-care-of-itself view of the question is not in a certain degree defensible.¹

Could the fundamental importance of the quantitative relation between capital and natural resources in determining

¹ *Geological Survey of Michigan*, vol. i, p. 247.

methods be more clearly illustrated than in this striking quotation?

The second advantage was the fact that the preliminary work was of the "simplest and safest kind of pick-and-shovel, hammer-and-drill, horse-and-cart business, such as can be left to the common run of mine contractors." It required no skilled labor, a matter of importance in that remote district in those days. Marquette mining did not differ essentially from ordinary rock excavation, except in the skill and care required in sorting ore.

In the third place, great economy of drilling and explosives were permitted by high stopes in open works. Two-inch holes were sunk 15 or 22 feet. They were "shook" several times with small charges of powder to make cracks round the bottom, and finally the lifting charge of from five to ten 25-lb. kegs was put in. Sometimes twenty kegs were used at one time, and as much as 5,000 tons was brought down at once, a third of that amount being quite common. The ore was then broken up as previously described. The cost for drilling and explosives in the case of a single blast sometimes ran as low as \$0.03 a ton and as high as \$0.50, and the average cost of powder and fuse for the hard-ore mines was not believed to be more than \$0.10 a ton, which Major Brooks compares with a cost of \$0.65 for drilling and explosives at the Persberg mines in Sweden.

But the days of cheap open-pit mining were approaching their end even then. "An increase of water and greater cost of handling incident to increased depth, and, what is still more costly, the increase in thickness of the rock covering, will soon require, in fact does now (1870) really require, more expensive plants, different methods, and more skill."¹ The law of diminishing returns was silently at

¹ *Geological Survey of Michigan*, vol. i, p. 248.

work; the most cheaply worked ores were being mined out; but as resort was had to deeper workings, it was not possible to raise the price to make up for the increased cost. A 65 per cent ore was seldom worth more than \$4 to \$5 on cars at the mine, including royalty, and its price was to go down instead of up. What was to be done? But one thing was possible, namely, to apply more capital and improve methods so as to reduce cost.

§ 9. If the methods of breaking ore were inexpensive, the system of handling from the miners' hands to the cars was clumsy and expensive enough to make up. Though steam pumping and hoisting machinery was being installed in most of the Marquette mines at a cost of from \$6,000 to \$50,000, yet in 1870 not more than half the ore was handled by steam and much less than half of all the material. The horse and cart, swing derrick and whim, were in general use, and the roads were bad as to grades and surface. Again we see that the mines in those days were deficient in all that depended on an adequate supply of capital.

§ 10. The total expense of mining is placed by Major Brooks at about \$2.64 a gross ton. This includes delivering ore on the cars ready for shipment, but does not include interest on capital, expense of selling, royalty, or depreciation. The cost of mining the soft hematite ores is considerably less. This \$2.64 is analyzed into five main elements of cost, namely, dead work, \$.742; mining proper (labor), \$1.05; mining materials and implements (mine costs), \$.313; handling ore from miners' hands to cars and pumping, \$.413; management and general expenses, \$.122. These items deserve closer examination.

The general head of dead work includes all work and costs incident to getting ready to mine ore; that is, exploration, sinking shafts, drifts and tunnels, making roads for wagons, stripping earth and rock, or uncovering ore, mis-

cellaneous work and mine improvements. (a) Exploration was conducted without any system, and cost from \$.005 to \$.03 a ton. (b) Shaft sinking cost from \$.015 to \$.055 a ton, the lightness of the item being due to the fact that the deepest shaft in the region in 1870 was not over 75 feet. (c) Drifting and tunneling cost \$.16 a ton on the average, and varied more than any other item. (d) Wagon roads were often expensive, averaging \$.017, and running up to \$.04 a ton. (e) Stripping earth and rock was the largest single item, varying from \$.20 to \$.52 a ton, and necessarily increasing as the work advanced. The ordinary price was \$.50 a yard for earth and \$3 for jasper rock. Allowing \$.50 per ton of ore for stripping, an amount frequently exceeded, a foot of rock or three feet of earth could be stripped for every foot of ore. The waste was removed by horse and wagon, and was sometimes carelessly placed so that it had to be handled a second time. (f) Miscellaneous dead work included dwellings, shops, fences, tracks, trestle-works, pockets, docks, whims, skip-ways, and pumping machinery. It was estimated at \$.16 a ton, a figure believed by Major Brooks to be too small, and one that increased largely from that time onward.

Second comes mining proper, or breaking ore, costing \$1.05 a ton, or 40 per cent of the whole. It includes "all the labor incident to blasting the materials down from the solid ledge, breaking it up into fragments that it may be easily handled, the separation of the ore from the rock by hand, and loading." Drilling included (a) ledge or stope holes, those necessary in blasting the ore from the original bed, and (b) block holes, those made in the large masses thrown down by the blast in order to break them up into sizes suitable for handling. This cost varied from nothing to four-fifths of all the expense for drilling. At the Cleveland mine 200 block holes had been employed to one stope

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hole. Adding the labor of drilling block and stope holes to that required in sinking and drifting, the cost of drilling was not less than \$.40 a ton, equal to 15 per cent of the whole cost, or \$300,000 in 1870. Drilling was done entirely by hand, two strikers and a turner working together, and Major Brooks suggests the possible economy of power drills. The cost of drilling, though absolutely large, was small when compared with that in other mining regions, such as New York and Sweden, where it ran to \$1.25 and \$.40 a ton, or 40 per cent and 23 per cent respectively of the total cost; and that notwithstanding the fact that wages in Sweden were but \$.65 a day, or about one-fourth what was paid Lake Superior miners. (c) Sledging, sorting and loading the ore cost \$.35. (d) To handle the rock mixed with the ore cost on an average \$.25 a ton of ore. (e) \$.21 for miscellaneous work included the pay of foremen, repairs of tracks and roads, wheeling, tramping, hand-pumping and like expenses.

Materials and implements include (a and b) explosives and fuse, \$.095 a ton; (c) steel drills, \$.018; (d) other tools, including shovels, picks, crowbars, sledges and striking hammers, \$.043; (e) blacksmiths' supplies, \$.047; (f) blacksmiths' labor, partly chargeable to dead work, \$.11. Contrasting the \$.09 a ton for explosives with \$.145 and \$.15 in New York and Sweden, we note the economy due to high stopes in open works. The cost figures show that one keg of powder must have broken about 25 tons of ore. Nitroglycerine and giant powder were just coming in. Nitroglycerine was introduced in 1869, and more than 25,000 pounds were sold the next year.

Handling ore from the miners' hands to cars and pumping cost \$.413 a ton, as against \$.75 in some New Jersey mines and only \$.07 in the Persberg mines of Sweden. Hoisting and pumping were done by the same machinery,

power being furnished in part by men, in part by horses and in part by steam. Concerning the use of horses, Major Brooks waxed indignant over its wastefulness: "If ever there comes a period when our mines do not pay it may be due largely to horses." The facts in brief were these: Twelve engines, varying from 10 to 50 horse-power, were at work. Something over 350 horses were employed, and the total expense for team work was about \$250,000, "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." To work a horse a year cost the extraordinary sum of \$650, and it cost four times as much to handle material by horses as by steam. If now steam was so much cheaper, why this extensive use of horses? The reasons are simple enough. In opening up the mines, particularly where the extent of the deposits was undetermined, the use of the horse and cart was advantageous. Then came the war and the subsequent boom, with unlimited demand and high prices for ore.

Mine superintendents were given no time to plan or 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.

The day for such methods, Major Brooks maintained, had passed. He urged that at all mines where much horse labor was required, work should be suspended until steam machinery could be installed, arguing that it was better policy for a mine to net \$50,000 on 50,000 tons of ore than on 100,000 tons. But if the improvement required a year in the mak-

ing, a year's profits would be lost, and moreover, 1873 was coming. "Make hay while the sun shines," was the motto of our early capitalists, and it is not easy to prove that they were wrong. They trusted for profits to high prices while they lasted, and reduced cost only when obliged to do so by the fall of prices.

The fifth item, management and general expenses, includes salaries, office expenses and taxes paid in the mining region, but not the cost of selling ore.

To the cost of \$2.64 must be added \$.50 for royalty or depreciation, bringing the cost up to \$3.14. In 1870 there were few leased mines and royalties were not settled. The New York mine, a first-class specular ore, paid but \$.20 a ton; others as high as \$.75 for a lean hematite. As most of the mines were owned in fee simple, a charge should have been made for depreciation of at least \$.50 a ton.

If now we add to this \$3.14 the commission for selling, interest and exchange, insurance and expenses of the general office, the actual cost of hard specular ore on cars at the mine in 1870 stands at about \$3.50 a ton.

In addition it usually cost about \$1 a ton to ship ore from the mines to Marquette, while the lake charges to Cleveland ate up from \$2 to \$6.50 more of the price received. Charges by way of Escanaba varied little from the same totals. Swineford in 1870 put the total cost of transportation from the mines to Cleveland at \$4.25,¹ and we shall not be far out of the way in saying that the sum of rail and lake charges from 1866 to 1873 was generally between \$3 and \$5. Thus we arrive at a total cost of ore delivered in Cleveland of from \$6.50 to \$8.50. Prices varying from \$8 to \$10.50 and \$12 left the mine-owners an enormous profit.

§ 11. The essential facts of this period, as stated in the

¹Swineford, *Lake Superior Iron District*, 2nd edition (Marquette, 1871), p. 94.

preceding pages, furnish their own commentary. Marvelous undetermined natural resources, small capital, enormous demand and high prices, numerous companies, wasteful methods, high costs, large profits—such is the summary. Three mines shipping in 1863, 40 in 1873, worked by almost as many distinct companies—these are facts indicating the method of growth during this decade. In 1863 the three mines that made shipments averaged nearly 68,000 tons each; the 9 of 1866 and 1867 averaged 33,000 the first year and 52,000 the second; by 1872 the average shipment per mine of all mines had fallen to 29,000 tons, and the next year it dropped off still further to 25,000 tons. The extension of the industry was by the opening of small new mines as well as by enlarged working of the old ones. The capital of most of the companies at starting was less than \$100,000, in many cases much less; it was rapidly increased by the profits of operation. The smallness of capital necessitated the most meager equipment, while the high price of ore made the worst mining profitable. The superintendents bent their efforts to getting out ore, not to improving methods. The transportation companies with the rise in ore prices raised their charges and thus increased cost. Throughout the whole period exploitation pure and simple was the method of work employed, a method imposed upon the companies by the richness of their mines and the scantiness of their capital. So great were the opportunities afforded by the discovery of new mines that any one who could get together a few thousand dollars could begin mining on a small scale and could make money at it. Consequently new companies multiplied. With the boom after 1870 operations were extended on a scale unprecedented, and the surface mines were rapidly worked out. The period closed in 1873 with the mines at the very summit of their prosperity.

CHAPTER IV

THE PERIOD OF MODERATE CAPITAL: PREPARATION.

§ 1. The panic year, 1873, opened with brilliant anticipations in the iron business, but signs of trouble were not long wanting. European capital had become a little wary of railways extending a hundred miles beyond the limits of populated territory, and roads could not forever pay for rails out of expectations. As early as April the Eastern Iron Masters' Association, referring to "the present depression in all branches of trade," ascribed it to the prolonged stringency in the money market, which again they laid to the machinations of Wall Street, the importation of luxuries, the extravagance of the masses, and overtrading. In June a convention of pig-iron makers at Cleveland recommended the restriction of output, but in vain. For three years new furnaces had been rapidly going into blast, the demand had at last failed to increase as rapidly, and more iron was being made than could be marketed at prevailing prices. The damage was done, and the sag in values once begun could not be stayed.

Then came the financial panic. The suspension of Jay Cooke & Co. in September was immediately followed by the failure of forty banks and brokerage firms in New York and corresponding disasters elsewhere. It became all but impossible to get money, and in October the Cambria Iron Co., even then a strong concern, gave notice to its employees that as it was impossible to collect for iron sold or to sell for cash, it could not pay cash, but would make settlement in

supplies to the full amount of wages.¹ All iron prices fell greatly. No. 1 foundry pig, whose average price for September, 1872, was \$53.87, was worth but \$42.50 in September, 1873, and within two months suffered a further decline of \$10.

“The ore producers,” says the *Marquette Mining Journal*; “were stricken as with a thunderclap by the forfeiture of contracts and delay in the payment of drafts.” Notwithstanding the suddenness of the blow, the only immediate failure was that of the Cascade Company. Early in December the *Journal* remarks:

The financial panic has developed so far a much cheaper means of mining than has heretofore been practiced. Labor and materials will be less expensive, whilst the expense in opening the mines has, for the most part, been already paid. So that the old companies will be well prepared to meet a decline in prices, and the contingency cheerfully . . . There will be sufficient increase in shipments to compensate for all decline in prices.

To the same effect speaks Mr. Charles E. Wright:

Many new mines, though not altogether valueless, yet from want of capital, or from bad management, or that the quality of the ore which they afford was below the standard necessary to fulfil the requirements of the markets, have either maintained a precarious foothold, or have been obliged to suspend operations altogether—some never to be revived, and others, possibly, to renew work when more favorable times shall occur. But the old mines, those of strength and established reputation, have suffered very little diminution in their product.²

¹ *Iron Age*, Oct. 30, 1873.

² *Michigan Commissioner of Mineral Statistics*, Report for 1877-8, p. 45.

To sum up in a word the immediate results of the panic, development work ceased, production fell off almost 25 per cent in 1874, and yet further in 1875, and the number of mines reporting shipments declined from 40 in 1873 to 33 in 1874 and to 29 in 1875. The working force of those that continued operations was largely reduced, and only five mines showed a larger output in 1874 than in 1873.¹

§ 2. The five years following 1873 were a period of unbroken gloom for the iron industry of the whole world. As a writer in the *Iron Age* (Dec. 23, 1875) put it, "The world is, for a moment, literally gorged with iron." There were too many railroads, too many iron ships, too much iron-making machinery. Prices went down, down, down, the producer each year hoping against hope that they had at last struck bottom. All sorts of plans for holding them up were suggested. Pools, associations, combinations multiplied. There were organizations to restrain competition in bar iron, tacks, nails, steel rails, iron pipe, nuts, bolts and washers, carriage bolts, bridges, cutlery, and other lines.² But with a productive capacity of at least 3,500,000 tons at the beginning of 1877, and a consumption in 1876, including imports, of less than 2,000,000 tons, what availed any agreement? Some of the stronger companies kept on producing at a loss rather than see their trade go to their rivals. But there are limits to this process, as the failure of the strong Allentown Iron Co. in 1878 showed.

Only one course was possible—cost must be lowered. By cutting down wages, by reducing the price paid for ore and fuel, by enlarging and modernizing plant and by improving processes, a level of cost was reached by the end of 1878 that would have been considered impossible a few years earlier.

¹ *Mich. Com'r of Min. Stat.*, Report for 1877-8, chart.

² *Iron Age*, March 1, 1877.

Another change, and one no less important, was taking place at the same time. Connelsville coal was doing its work, and the day of anthracite iron was past forever. The sceptre of the iron trade passed from the Lehigh Valley to the headwaters of the Ohio. Even in 1872 Pittsburg consumed about a quarter of the entire make of pig-iron, and her nine furnaces, not equal to more than a fourth of the demand of her mills and foundries, had to be reinforced by the building of new stacks, so that her production of the pig metal, despite the steady decline in price, slowly rose through all these years. The malady from which the Lehigh iron-masters suffered was not simply too much iron, but too much Pittsburg iron, and more especially too much Bessemer iron.

For a third most significant change was occurring in the rapid substitution of steel for iron, a consequent decrease in the consumption of the phosphoric product of the eastern furnaces, and a corresponding rise in the demand for western irons, smelted from the pure ores of Lake Superior, low in phosphorus and sulphur.

The years of depression, accordingly, while they bore heavily on the Lake Superior mines, worked ultimately to their advantage by rapidly forcing out the iron producers of eastern Pennsylvania. Though ore prices fell sharply, yet during all the years up to 1883 the ore men by reason of the steadily increasing demand for the Bessemer product had rather the better of the furnace owners, who regularly complained that the mining companies were not bearing their share of the price reduction.

§ 3. The rich specular Bessemer ore of the great Republic mine was most keenly sought after and for years the action of the directors of this company ruled the market, other companies adjusting their price to that set by the Republic. It will be remembered that hard ore was quoted at \$15.50

in December, 1872, and was generally contracted at \$12 for the next year. If we take the season contract price of Republic ore on the Cleveland docks as compiled from the books of a furnace company which was a regular customer of the great mine, and reported by a writer in the *Iron Age*, we find the following remarkable changes:

1873.....	\$12.50
1874.....	8.75
1875.....	7.50
1876.....	7.00
1877.....	7.00
1878.....	7.00
1879.....	10.00 ¹
1880.....	10.00
1881.....	10.00
1882.....	10.00

The usual terms were four months, the buyer being obliged to contract in advance for the whole season's supply. Unfortunately no data are at hand for an exact comparison with the years before 1873, but by an examination of the figures given by the Michigan Commissioner of Mineral Statistics it is evident that during the five years following the panic, hard Bessemer ore declined not less than \$2 to \$2.50 as compared with the average of the eight preceding years. Hematites and non-Bessemer ores suffered even more severely.

The position of the ore producers was evidently somewhat weakened during these years by increased production in the face of a narrowing pig-iron market; for by the middle of October, 1877, the docks at Cleveland were filled fuller than ever before, with specular Bessemer ores selling readily at \$6 and \$6.50, but hematites in surplus at \$4 and even less.*

¹ The correctness of this figure is doubtful.

² *Iron Age*, Oct. 18, 1877.

The next spring we find the *Marquette Mining Journal* complaining that the ore men no longer insist on season contracts but ship to the lower lakes on consignment, a practice which, the *Journal* correctly enough argues, will place them at the mercy of the furnace-men.

A new depressing force appeared that same spring in the expected competition of the Menominee mines, first opened up in 1877. Iron had been discovered on this range as far back as 1846, but nothing was done for a generation, and at the beginning of 1878 only three mines had been opened even partially. The quality of the ore being unknown and the mines in some cases controlled by Marquette parties, the competition assumed little actual importance in 1878.

The Republic directors had announced a cash price for the season of \$6.50, \$.50 less than in 1877, while hematite sales were reported at \$4. By June the ore trade had almost stopped, and lake charters, which had started at \$1.40 a ton, were down to \$1.10 and \$1. Bottom was reached at last, and prices held fairly well the season through at about \$6.50 and \$6 for magnetic and specular ores and \$4.50 and \$4 for hematites. The growing Bessemer steel industry, which multiplied more than fourfold from 1873 to 1878, never halting for panic or depression, stayed the decline in the better ores, and their strength sustained the price of poorer ones.

§ 4. To understand clearly the Lake Superior mining problem during these five dark years and the manner in which that problem was solved, it must be remembered that the effects of the law of diminishing returns were for the first time beginning to be severely felt, and that lower price went hand in hand with higher cost. In 1873 but one mine in the whole Marquette district was worked underground; sixteen years later underground work was the rule rather than the exception. What this means in the way of in-

creased cost and larger capital investment has already been pointed out.

The Jackson mine by 1880 had a railroad track running through a tunnel 500 feet long into the mine so that the cars could be drawn in and out by a small locomotive. The ore was trammed from the workings to four ore pockets, whence it descended by chutes into the cars. Power drills were not employed until eight years later.

At the Cleveland, hand drilling had already been given up by 1880, the mine was operated by electricity and the ore was run up to the surface on skips. The company, besides operating two locomotives and six steamboats, had its own dock at Marquette, and during the next few years it continued to add valuable new machinery and buildings.¹

§ 5. What was happening to the weaker companies during the years of depression may be shown by an illustration or two. Of the Spurr mine the Commissioner says in his report for 1877-78:

The mine has been laboring under one very serious embarrassment, and that is a lack of ready capital. The first result of this is in not having sufficient new ground opened ahead to mine advantageously. Secondly, a higher price must be paid for labor, and thirdly, labor in reality "running the mine," and accomplishing less for a day's work, thereby lessening the capacity of the mine.

The Kloman mine, opened in 1873 by Andrew Carnegie's first partner, operated two seasons and then, to everybody's surprise, shut down. Kloman was in financial difficulties and had to relinquish control of his property.

The Washington Company, organized in 1865 with a nominal capital of \$500,000, of which a fifth was paid in, had a promising mine, in improving which it had spent all

¹ See reports *Mich. Com'r of Min. Statistics*.

its surplus earnings. "The mine was just in good shape for a large and economic production when the panic occurred, and the company found it impossible to continue mining operations. The mine, which we regard as one of the best in the district, is for sale or lease on favorable terms."¹

Illustrations might be multiplied, but enough has been said to show that the one thing essential during these years was an abundance of capital, that those companies which had capital passed through the depression without any especial difficulty, while those which lacked it had to close down their mines and sell out, no matter how valuable their properties might have been if properly equipped. That the established mines were not working at a loss is shown by the fact that their product began to increase slowly after 1875, though the low point in price was not reached till 1878.

§ 6. The next year witnessed the beginning of a short-lived boom. Every one entered upon the year with confidence, though but 37 per cent of the furnaces were in blast in May.² Railroad-building, which had not equalled 3,000 miles in any year since 1873, rose to 4,817 miles, and in 1880 to 6,712. Iron prices rose rapidly, no. 1 foundry at Philadelphia climbing from an average of \$17.67 per ton in 1878 to \$41 in February, 1880.

England had been passing through a depression of almost unparalleled severity, and with the rapid rise of prices on this side of the Atlantic, her iron-makers sought relief for their overstocked yards by sending their product to the United States. Imports of iron and steel, whose value had been only \$18,000,000 in 1878, and since 1873 had averaged but \$24,000,000 a year, came pouring in, despite the

¹ Swinford, *Mineral Resources*, p. 205.

² *Iron Age*, May 29, 1879.

tariff wall, at the rate of more than \$80,000,000 in 1880, the flood literally overwhelming our iron industry. For a time prices dragged and the iron men feared that the days of the middle seventies were about to return.

Things were by no means so bad as they looked. With good crops taxing the facilities of the western railroads, almost 10,000 miles of rails were laid down in 1881 and 11,569 the next year. Intrenched behind a \$28 tariff fortification and able to command an average price of \$67.50 for rails in 1880, \$61.13 in 1881, and \$48.50 the following year, the Bessemer steel monopoly in 1882 doubled its output of 1879, and the western furnaces had to keep the pace.

Driven by the incessant demand of the yawning Bessemer converters the Pittsburg furnace-men revolutionized their methods, and it is no mere figure of speech when Axel Sahlin says, "Modern iron-making in America began when in 1881 the long-doubted rumor became certainty that the late Captain William Jones and Julian Kennedy had by means of high heats and large volume of blast succeeded in more than doubling the output of the Edgar Thomson furnaces, without altering the plant."¹

With the rapid rise in the value of pig-iron and an almost unlimited demand from the steel-makers of Pittsburg, ore prices were bound to go up. The 1879 figure for Republic was fixed at \$7.50; by the end of the season the furnace-men were paying \$12 or \$13 for odd lots, and the next season's supply was contracted at prices ranging from \$12.50 to \$10, but the slump due to the heavy imports compelled the furnace-men to get their ore at a cheaper rate, and the ore companies reduced the price on these contracts as much as \$2.50 and \$3. The Commissioner's report gives the 1880 price of standard Bessemer ores at \$9.25 and that of the

¹ *American Industrial Conditions and Competition*, edited by J Stephen Jeans (London, 1902), p. 400.

two following seasons at \$9. The Republic price for 1881 was fixed at \$10, and its product the next year commanded the same figure, other ores bringing proportionate prices.

The high prices of these years greatly stimulated ore importation. Before 1879 our imports had been negligible; that year they reached almost 300,000 tons and in 1881 rose to nearly 800,000, falling off by 25 per cent the following year. Such importations came largely from Spain and had little effect upon the Lake Superior product except to limit its market east of the Alleghenies, some large consumers finding it cheaper to use the foreign ore even with a 20 per cent duty added than to pay the exorbitant prices demanded by the ore lords. The heavy expense incident to hauling ore by rail the four hundred miles from the Atlantic coast to Pittsburg gave the Lake Superior ores a far more effective protection in their chief market than any afforded by friendly tariff legislation.

§ 7. As a result of rising prices a great stimulus was given to prospecting and development work. The number of mines on the Marquette rose from a low point of 29 in the years 1875-77 to 48 in 1882, while the shipments increased 80 per cent from 1878 to 1882. On the newly-opened Menominee range the development was yet more remarkable. In its first year, 1877, two mines made shipments and the next year eight sent down nearly 100,000 tons; in 1882 its 24 mines showed an output of more than ten times that amount.

The permanent expansion of demand had notable results for the mines, if we view the matter from the standpoint of our theory; for it meant that the surface workings of each new property were quickly exhausted, and that it became more and more necessary for the companies to put in adequate machinery. This step alone could enable them to raise a large product yearly over a long period of time.

That this is no mere theoretical consideration is shown by a statement of the *Ishpeming Agitator* in 1883. The big new hematite mines, so says the *Agitator*, are usually cheaply worked by the open-pit method for a couple of seasons—in the earlier days of small output this period would have lasted a decade or longer—and their cheap product is thrown on the market, depressing the price of hematites, and with it the price of hard ores. Then the new mines must go underground, begin timbering and get their ore at double the cost.

The increased production per mine, with its consequent necessity of underground work, is shown by the table of shipments. During the second half of the seventies the average shipment per mine varied between 30,000 and 35,000 tons; in 1882 it stood at 41,000, and it slowly rose to 50,000 in 1887, after which it quickly doubled.

§ 8. The general condition of the iron industry during the ten years from 1883 to 1892 will not be considered in detail, as it presents little that is of importance for our purpose, though the ore situation during the decade is of the greatest interest. It will be enough to say that with the exception of a spurt in 1887, due chiefly to the unprecedented activity in railway building which resulted in the laying of the record number of 12,872 miles of track, iron and steel manufacture was characterized during the entire period by a condition of quietness, not to say dulness, which brought a steady sag of prices, the average of the yearly average values of steel rails under the reduced duty of \$17 being \$33.72 for the first five years and \$30.15 for the second, the corresponding figures for pig-iron standing at \$20 and \$17.66.

Notwithstanding the quiet or comparative depression that characterized this time, the industry was making remarkable progress. The production of pig-iron doubled, that of Bes-

semer steel nearly trebled, and the output of open-hearth steel increased six-fold within the brief space of ten years, because of a cheapening of the cost of production by improvements in methods and machinery which gave the United States the first place among the world's iron producers. Our output of the pig-metal for the first time surpassed that of Great Britain in 1890.

§ 9. In 1883 there had been completed a work of the greatest importance to the iron manufacture, and more especially to the Lake Superior mining industry. Up to 1881 all the ore except the comparatively small amount shipped by rail had to pass through the old Sault canal constructed in 1855 to accommodate 12-foot ships. By the year 1870 vessels had grown so that only one could pass through at a lockage instead of the three of early days, and moreover they could not carry full loads on 12 feet of water. Accordingly Congress made an appropriation for the building of a new lock 515 feet long and 16 feet deep. After the expenditure of \$2,171,084.44 the new lock was completed, and the first vessel passed through on September 11, 1881. The state of Michigan, which controlled the old canal, had meantime ceded it to the government, whereupon all tolls were abolished and both canals made free. During the next two years, by an additional expenditure of \$200,000, the channel below the canal was deepened to 16 feet, thus making navigation fully possible for steamers drawing that depth of water.

The new lock had a capacity of 96 vessels in 24 hours, and when begun was expected, in conjunction with the old locks, to prove fully adequate to all demands. But no sooner was the new lock finished than the old ones became practically useless. The largest vessel loading at Marquette in 1872 carried 1,100 tons. The 16-foot canal made possible the 3,000-ton steamer, and within two years after the

new lock was finished only 11 per cent of the commerce passing through the straits was carried in vessels small enough to go through the old locks. Within a few years freight was being carried from Duluth to Buffalo at .15 of a mill per ton-mile, or about one twenty-sixth the rate on the best-managed railroad in the United States.

The exact effect of the canal improvement on the price of ore cannot be stated. It was estimated that in the first year after the deepening of the channel there was a saving of \$800,000 on the transportation of ore, approximately \$.30 a ton. The division of this saving among mine-operators, vessel-owners, furnace-men and consumers is a matter that no scrutiny of figures will disclose. At any rate we know that cheaper transportation gave a margin for reduction in the price of ore and thus hastened the deepening of the mines and the necessity for larger capital.¹

§ 10. To resume the discussion of conditions in the ore market at the point where we left it, we find that during 1882 the demand gradually weakened, and the 25 per cent increase over the shipments of the previous year proved more than the market could stand. The next spring the furnace-men, by holding off, for once got the better of the ore-producers, and prices of ore in April, 1883, were from \$2 to \$2.50 lower than during the preceding year. The mines turned off a third of their working force and prepared for a dull season.² The year showed a falling-off in shipments of 600,000 tons, and there was little growth in the next two years, with the price of pig-iron steadily going down almost to the low point of 1878.

The immense profits of the years up to 1882, however,

¹ For the full history of the Sault canal see the annual reports of the Chief of Engineers of the U. S., especially 1877 *et seq.*

² *Mich. Com'r of Min. Stat.*, 1882, p. 214.

sent thousands of dollars into new mining fields and resulted in the opening up of the Vermilion and Gogebic ranges, which were developed under conditions so widely dissimilar as to make their study peculiarly instructive for our purpose.

The Gogebic deposits, lying 40 miles southwest of Ashland, and crossing the Michigan-Wisconsin line, had been frequently noted by geologists from 1848 on, but the inaccessibility of the range and the extreme rigor of the climate combined to delay any actual development until the fall of 1884, when the first ore from the Colby mine was sent on six flat cars to Milwaukee. In the autumn of 1885 the Milwaukee, Lake Shore & Western was finished from the mines to Ashland, and the Gogebic was fairly started on its meteoric career with shipments of over 100,000 tons. The new range had remarkable deposits of soft red hematite ores high in iron and low in phosphorus, eminently suited to the Bessemer process.

The railroad running parallel to the strike of the ore deposits gave ready opportunity for a mine opened up anywhere along the range to get its ore to market. The first mining companies lacked capital. The result of these two circumstances was the most remarkable speculation in the history of Lake Superior iron-mining.

In 1886, Capt. N. D. Moore and John E. Burton, who had more faith in the future of the district than they had capital, began an aggressive campaign of advertising to raise money for developing the mines, and within a year companies were formed with a nominal capital of more than \$100,000,000.

A common method of work was for explorers to take an option on a property and spend a considerable sum in exploration; if the showing of ore was good, the option would be sold to a company to work on royalty, as the owners

usually held their land at prohibitive prices. The purchaser got the right to mine ore on payment of a royalty of \$.50 or more a ton to the owner of the fee. Thus Mr. Birkinbine tells of one case in which an option was taken and \$1,800 spent in exploration. Then the explorers sold out their option for \$100,000.¹

Similar cases were common enough in those days. Mines which had shipped scarcely a ton of ore were held at all the way from \$450,000 to \$700,000. When it is remembered that mining property ought to yield 20 per cent, and when it is further realized that to be worth \$500,000 a mine would have to ship 100,000 tons a year for five years at \$1 profit, in order simply to repay the capital, to say nothing of interest, it will be recognized what madness seized the buyers of Gogebic stocks in 1886. Men confidently expected to find a Colby or a Norrie on every claim, and drills were set to work in places where the most ordinary knowledge of the geology of the district would have convinced any sane man that no ore could possibly be found at a less depth than half a mile. Every eighty along the range where ore was found was capitalized for \$1,000,000 and its stocks placed before the "investing" public. So-called "option-stocks" were sold as low as three cents on a dollar.²

At the height of the excitement in the summer of 1887 a magnificent scheme of combination was launched. The Lake Superior Consolidated Company and the Bessemer Consolidated Iron Company were formed to take over mines having an annual output of 880,000 tons (but not including the largest and best of all, the Colby, Ashland, Norrie and Aurora). For the mines so acquired the companies were

¹ *Iron Age*, Jan. 6, 1887.

² For a description of this speculation see articles by John Birkinbine in *Iron Age*, Dec. 2, 9, 16 and 30, 1886, and Jan. 6, 1887.

to pay \$6,870,000, and on this basis were to issue stock and bonds to the extent of \$17,500,000. The Great Lakes Steam Shipping Company was to be organized with a capital of \$4,000,000 and the Lake Superior Consolidated was to loan it money to build 15 large vessels, getting in return \$3,000,000 in bonds of the steamship company. The latter was to have a five-year contract with the Consolidated to carry 600,000 tons a year at \$1.50, and a like contract with the Bessemer Consolidated and the Aurora Mining Company for 300,000 tons. Truly a pretty scheme—the one difficulty with it being that the mines, which constituted the only real basis of value, were bought at a price from two to four times their actual worth, and this price was represented two and a half times over in the capitalization.¹

The inevitable quickly came to pass, and in October, 1887, we find the *Iron Age* editorially remarking: “The end appears to have come. With the exception of perhaps a dozen of the largest and best, the mines of this district have been compelled to shut down, and hundreds of men have been thrown out of employment.” Stocks which a few months before had been selling for \$5 a share went begging at \$.20, others had no quotable value; the unlucky investors in mining securities lost all they had put into them, and the very name Gogebic became a hissing and a by-word in the iron world.

With the details of this speculation and its financial results we are less concerned than with its practical effects on the cost and price of ore and the ownership of the mines.

§ 11. First of all the Gogebic mines were in almost all cases saddled with heavy royalties, ranging from \$.30 to \$.75 a ton, in general \$.50, with a guaranteed output of 10,000 tons. The fee-holders, who had mines, or rather

¹ *Iron Age*, Aug. 18, 1887.

prospects, but no money, instead of selling outright even at phenomenal figures, preferred to levy an annual tax on the inrushing capital, and the result was that \$.50 for royalty was added to the cost of every ton of Gogebic ore.

In the second place the surface deposits were quickly worked out. Many of the mines were managed with a view to the sale of stocks rather than of ore. To sell securities, "records" were necessary, and hence the mining captains strained every nerve to attain the maximum output possible the first year. The product of 1885 was less than 125,000 tons; that of 1886 almost 750,000; of 1887 over 1,700,000. The mines were "skinned" of their cheaply-worked ores with a rapidity almost inconceivable, and the product was thrown on the market with a reckless disregard of the future.

No other course, indeed, was possible under the system adopted, for the companies lacked capital and the public had to be induced to furnish it. An output of 100,000 tons was a far more convincing argument than a mine in which a large amount of capital had been sunk with only a small immediate return. Precisely the same thing was enacted on a small scale as took place on a far grander one in the case of the industrial companies a dozen years later, and the financial results were not dissimilar. In the mines the day of underground work was hastened, with results that must now be described.

The data are furnished in the articles of Mr. John Birkinbine previously mentioned.¹ He made a careful examination of both the Gogebic and the Vermilion mines in the fall of 1886.

On the Gogebic, machinery and methods were not so poor as might have been expected. Practically no ore that

¹See also Birkinbine, "Resources of the Lake Superior Region" in *Transactions of Am. Inst. Min. Eng'rs*, vol. xxi, pp. 644-686.

ran below 60 per cent iron and above .06 per cent phosphorus had been shipped, and owing to its remarkable uniformity little sorting was required.

The actual cost of mining by the open-cut method did not run above \$.50 a ton in some cases, but even at this early date most of the mines had to be making preparations for underground work. Wages were high, and on the basis of \$2 a day for labor it was figured that the cost of mining per ton over a series of years would run as follows:

Underground labor	\$1.10
Timbering40
Surface labor13
Superintendence and office expenses17
Fuel, light, supplies, <i>etc.</i>20
Maintenance of machinery and equipment10
Total	<u>\$2.10</u>

“Outside of the open-pit works,” says Mr. Birkinbine, “the ore now mined on the Gogebic iron range probably costs from \$2 to \$2.50 per ton, an average being about \$2.20 per ton, to which add royalty, say \$.50.” To this cost of \$2.70 on board cars at the mines must be added the railroad freight to Ashland, \$.80, and the lake rate to Cleveland, which on season contracts was \$1.20, the average wild rates for that year being no less than \$1.78. To quote Mr. Birkinbine again:

Allowing for transportation to Cleveland, dock charges and commission, it is probable that the average of the Gogebic mines can be delivered at Cleveland for \$5 per ton; some of the mines cannot produce ore at the above figures; . . . there is little probability that it will be good policy to operate numerous small mines under independent management, but the consolidation of adjacent properties will result in a material reduction of fixed charges.

Writing about the middle of 1887, Mr. Kirchhoff says that the days of cheap open-cut mining on the Gogebic are virtually over, and the mines that turned out ore for \$.50 cannot do better than \$1. The Colby in 1886 averaged \$.87, but now not a mine in the district can beat a dollar, and including royalty their ore costs them \$1.50 to \$2 to mine. Under the best conditions it can be laid down at Cleveland for \$4, but probably not a company is doing that this year, the cost to the better mines being about \$5 and \$5.25.¹

With the best Gogebic Bessemer ore selling in Cleveland in 1886 at \$5, in 1887 at \$6, and in 1888 falling to \$4.75, it will easily be seen how extravagant were the golden dreams of the early days, how utterly impossible it was for the new mines to maintain their position except by prompt and large investments of capital to insure extensive and permanent output. No combination to keep up prices could avail anything, for the Gogebic ores had no monopoly.

§ 12. The collapse of the latter part of 1887 has already been mentioned. The ore taken out carelessly by some of the companies was not up to grade, and the furnace-men refused payment; the mines could not collect for ore sold; a strike among coke-workers and ore-handlers on the docks caused further delay; a phenomenal rise in lake freights increased the demand for available funds; creditors became clamorous; and one universal cry went up from the Gogebic companies—more cash! Simply because they could not command the necessary capital their whole industry went down in one tremendous crash. The Bessemer Consolidated scheme was “laid off for repairs,” while the Lake Superior Consolidated in February, 1888, threw up its options and transferred the Moore-Benjamin properties back

¹ *Iron Age*, Aug. 11, 1887.

to their original owners, who had meanwhile gone into the hands of a receiver. The Burton mines, the basis of the Bessemer Company, were loaded down with mortgage bonds for the sake of raising cash.

The cataclysm carried down large numbers of the smaller companies and demonstrated once for all the folly of undertaking to carry on mining without adequate capital, and the worse folly of trying to raise the needed funds out of anticipated profits by speculative methods. The stronger companies weathered the storm; the Metropolitan Land and Iron Company coming through in successful possession of the great Norrie and Pabst mines, as well as other important deposits, and a syndicate closely affiliated with the Wisconsin Central Railroad holding the Colby, Ashland, Aurora, Palms and Superior mines.

§ 13. A striking contrast with this story of small individual and corporate enterprise, inadequate capital, reckless speculation and widely distributed loss is afforded by the history of the Vermilion mines, opened a year ahead of the Gogebic. Owned from the beginning by a single strong company, which also controlled the only transportation line, these mines were from the first worked with adequate capital, they were regularly and systematically developed, their ore was marketed with due regard to trade conditions, and as a result the company made money from the start.

A comparison of the output of the two ranges by years discloses an interesting contrast between centralized control backed by adequate capital and competitive exploitation based on small undertakings and insufficient funds. The Gogebic, which was not really opened up till 1885, in the second year following produced more than a million tons; the Vermilion, though opened a year earlier, did not reach the million mark till 1892, when the Gogebic produced almost three millions, only to fall off to less than half that

amount the next year. Production on the Gogebic moves upward by leaps and starts, one season rising to excess, the next sinking back to deficiency; the output of the Vermilion, on the other hand, climbs with a regularity that is surprising when one considers the variable conditions of the market in which it had to be sold.

§ 14. The Vermilion ores, mentioned in geological reports as far back as 1850, lay untouched until 1875, and nothing of importance was accomplished in the district until the stimulus of high prices was felt in the early eighties. Lying a hundred miles away to the north of Duluth, in the midst of a wilderness almost impassable save by explorers on foot or in canoes, the region was looked upon by practical mining men as an impossible proposition. Late in 1884 the *Ishpeming Agitator* said that if the Marquette and Menominee mines two years earlier had begun increasing output and lowering prices the Vermilion range would never have been opened, and as it was, could never make any money.

But there were men of foresight and courage and capital who formed the Minnesota Iron Company, and in 1882 began building the Duluth & Iron Range Railroad over the 68 miles of wilderness and swamp between Two Harbors and Tower. The road was substantially built, laid with 60-pound steel rails, well ballasted, equipped with 24-ton ore cars and consolidation locomotives which hauled 500 tons. A great ore dock was built at Two Harbors, and when the railroad in 1884 reached Tower and the company was ready to begin shipments it was estimated that it had spent no less than \$3,000,000.

What was the condition justifying this vast expenditure? The company had opened up a great deposit of rich, hard, largely Bessemer ore containing 3 or 4 per cent more iron and also somewhat more phosphorus than the famous Goge-

bic hematites. In the beginning of 1887 the company had a contract calling for 135,000 tons of ore not below 67½ per cent nor above .06 per cent phosphorus, 200,000 tons containing 67 per cent iron and phosphorus not to exceed .06 per cent, and 40,000 to 50,000 tons running 62 to 64 per cent iron with no limit as to phosphorus. Such a contract gives some conception of the quantity and quality of the ores, which were found covered with a light mantle of glacial drift, averaging but 8 feet in thickness and in no case running above 25. The ore was so hard that it had to be blasted with dynamite and nitroglycerine and run through a crusher.

§ 15. The company opened all its mines as open quarries, but with the intention from the first of working them underground as soon as it should prove economical. By the early part of 1887 when Mr. Birkinbine visited the mines there were installed two air-compressors operating 30 Ingersoll power drills, six engines driving as many 5-foot hoisting drums, a range hoist working eleven skips and hoists, and an electric-light plant, to say nothing of other equipment.¹ As a result of such preparation the company was able rapidly and steadily to enlarge its output, and at a good profit.

A comparison with the Gogebic shows that there was no wide difference over a series of years in the cost of putting the product of the two districts on board lake vessels. The Vermilion ore being very hard cost three times as much for explosives as the soft Gogebic deposits, but it also furnished pillars of ore and so made timbering unnecessary. The entire product of the Minnesota mines had to be stock-piled during the winter, and the expense of rehandling, added to the cost of mining, hoisting ore and waste rock, filling, explosives, drill steel, smiths' waste, fuel for engines, and

¹ *Iron Age*, Aug. 4, 1887.

other expenses, brought the cost on the cars up close to \$2. This figure is based on underground and not on open-pit work. Estimating the cost of the haul to the lake at a minimum of \$1 (a minimum that was very quickly lowered) the cost of ore on the vessel was \$3, which added to the contract lake rate of \$2, gave \$5 at Cleveland, or just about the cost of Gogebic ores at the same place.¹ It should be noted that the best Minnesota ore, because of its hardness, was considerably more valuable than the Gogebic product.

One thing must be evident, and that is the careful, conservative and yet courageous way in which the Vermilion range was developed, as compared with the hasty, ill-considered and reckless opening of mines on the Gogebic. The Vermilion mines were an industrial undertaking, the Gogebic a financial; the Vermilion mines were worked to make profits by mining, the Gogebic by selling stocks; the Vermilion mines belonged to one corporation, the Gogebic to threescore. While other things are in part responsible for the difference between the two, yet the fundamental fact is that on the Vermilion one company began operations with capital adequate to the work before it, and on the Gogebic the capital, though enormous in the aggregate, was yet so scattered and divided up as to be quite insufficient for effective work.

§ 16. A few words further should be said concerning Vermilion history up to 1893. So successful was the Minnesota Iron Company that interests identified with the Illinois Steel Company, who had been threatening to build a railroad from Duluth to the range and mine on their own account, in 1887 determined instead to buy up the old company and its subsidiary railroad, paying for them a sum re-

¹ *Iron Age*, Aug. 4, 1887.

ported to be not less than \$7,500,000. The same year the railroad was extended to Ely, 21 miles east of Tower, where the wonderful Chandler mine had been opened and promptly snapped up as a leasehold by the Minnesota Company. With that company controlling the only railroad, it is evident that competition with it, except by sufferance, was a virtual impossibility.

When the Minnesota Iron Company in January, 1888, applied for the listing of its securities on the Stock Exchange it was able to report itself as owning 14,270 acres of land, with equipment to mine 500,000 tons of ore, \$4,400,000 worth of Duluth and Iron Range securities, and \$1,780,000.21 of operating assets. It had issued \$14,000,000 out of an authorized \$20,000,000 worth of capital stock. During 1887 it had mined 394,252 tons of ore at a cost of \$2.02, shipped them to Cleveland at an added cost of \$3.10, and sold them for about \$6.30, giving it a profit on the year's business of \$470,685.34.

The company made contracts with two large allied steel interests whereby it sent its ore east of Buffalo. The advantages of centralized management and affiliation with manufacturers were beginning to show. In order to prevent loss of money through payment of exorbitant lake charges as in 1887, the iron company organized the Minnesota Steamship Company and built six large vessels with an insurance value of \$1,200,000. Once again the connection between capital and economy becomes apparent.

Meantime what was the position of the company on the range? In 1889-90 there was a small boom in Vermilion mining stocks and some people imagined that there was to be a repetition of the Gogebic craze. As a matter of fact, many of the small companies forming were subsidiary corporations of the one great concern, organized to evade a provision of the Minnesota law which forbade any com-

pany to own more than 5,000 acres of land, and the rest of them were mostly small stock-jobbing affairs. The *Iron Age* of April 24, 1890, summed up the whole matter well: "The Minnesota Iron Company and the Minnesota Exploration Company are separate organizations, but of the same great parents. The Iron Range Railway of 120 miles belongs to the same syndicates; the ore docks at Two Harbors, everything of value almost on the range, is in the hands of one of the two Minnesotas." The ownership of the railroad made the company impregnable save against a competitor prepared to duplicate not only its capital, but its mines as well—and they have yet to be duplicated in the district.

§ 17. The ten years following the deepening of the canal witnessed a complete change in lake navigation. During 1884-5 the vessel business, with the general dulness prevailing, was so unremunerative that every one who could do so got out of it, but the next year the situation was reversed. The opening of the new ranges made necessary an ore haul longer by 200 miles, while the demands of the grain trade on the vessel-men also increased. With contract rates from the head of the lakes on ore charters at \$1.20 for the season and wild or daily rates averaging \$1.78, the profits of the vessel-men were in some cases as much as 25 per cent, and a boom in building was the result. In March, 1887, there were under contract at the lake yards no less than 47 vessels with a capacity of 98,200 tons, costing \$6,440,000. This enlargement of the fleet was by no means sufficient to meet the added demands of the next season, and consequently the ship-owners were able to exact a season rate of \$2 from the head of the lakes, while those luckless mining companies which had no contracts paid on the average \$.23 more, charters in some instances going as high as \$3.05. Contract rates from Marquette in 1885 were

\$1.05; in 1887 they were \$1.63, with wild rates averaging \$1.87. The contract rate from Escanaba rose from \$.90 in 1885 to \$1.40 in 1887, while daily rates, which in 1885 averaged but \$.78, in 1887 stood at twice that figure, or \$1.59.¹ Small wonder the mine-owners thought that they were doing business simply for the benefit of the vessel-men and small wonder that 200 ships were launched for the lake trade within three years.

More remarkable than the increase in the number of vessels was their growth in size. In 1888 there was one vessel carrying 3,000 tons, there were a score carrying 2,500 or more, and 100 with a capacity of more than 2,000 tons.² Of those building in February, 1890, the *Iron Age* states that the average capacity was from 3,500 to 4,000 tons. The steamer "Maryland" during the preceding year had made a record by bringing down 3,250 tons of ore on a draft of 16 feet.

The Minnesota, the Lake Superior, the Cleveland, and other iron companies had fleets of their own, and the railroad companies, too, were entering the navigation business.

§ 18. We turn again to trace the course of the ore trade after the boom which culminated in 1882. Depression and declining prices characterize the next three years, the shipments of 1885 being half a million tons less than those of 1882. 1886 saw a considerable improvement, while 1887 marked a further rise in prices, almost all of which was eaten up by higher transportation charges. The boom of that year enabled the furnaces not only to absorb the product of the new ranges, but also to consume largely increased

¹ For vessel rates 1882-1901, see *Mich. Com'r Min. Stat.*, rep. for 1901, p. 33.

² For statistics of shipbuilding on the Great Lakes see the *Marine Review*.

amounts from the old ores, besides using almost 1,200,000 tons of imported ore.

Despite the low prices of the next two years, pig-iron during a part of 1889 being at the lowest figure ever known up to that time, the demand for ore steadily increased, and notwithstanding the fact that the best Bessemer ore did not command more than \$5.50 and \$5.75, the mining companies made large profits. The mines, like the furnaces, were down to a new cost level, and during 1889 even the new ones made about \$1 a ton, while the old ones did even better. The Metropolitan Land and Iron Company, the great Gogebic concern, declared a dividend of \$6.50 on its \$25 shares, which were quoted close to \$75. In the fifteen months beginning January 1, 1889, the Pittsburg and Lake Angeline Company, one of the old-established Marquette corporations, paid its stockholders \$35.50 a share, or at the rate of about 114 per cent per annum. Its shares were quoted at 175, and its half million of capital was worth seven times that amount.¹

The iron companies were not distributing all their gains in dividends, however; the best managed ones were putting them into improvements. The Lake Superior Iron Company in 1889 built two 2,400-ton steel ships at Cleveland, costing \$170,000 each, while the Minnesota Iron Company invested \$880,000 in the construction of four vessels of 2,800 tons burden, with the purpose of swelling profits by adding vessel earnings.

The "big year," 1890, brought a recovery in price of about \$1 a ton, and 9,000,000 tons of ore came down the lakes, the Marquette and the Gogebic each furnishing about a third. Almost 4,000,000 tons were left on the docks when navigation closed, and the next season's supply was con-

¹ *Mich. Com'r Min. Stat.*, Report for 1889.

tracted at a reduction of \$1 from the figures of 1890; matters looked so doubtful for the ore companies that they cut their working force largely, and many of them passed their dividends, so as to have cash on hand if needed. They were in so much stronger financial position than four years before that they adjusted themselves to the changed conditions without special difficulty, cutting the year's shipments to 7,000,000 tons, and raising them to 9,000,000 the following season in spite of the fact that they did not realize any higher price for the product, no. 1 Vermilion Bessemer bringing but \$5.65 and non-Bessemer hematite \$3.75. There could be no more striking proof of the reduction of cost since the days of 1873, when a fall in the price of Bessemer ore from \$12 to \$9 shut up almost half the mines of the whole region.

§ 19. An interesting event, and one significant as the forerunner of a whole series of like changes that were to come a few years later, occurred in May, 1891, when the Cleveland Iron Company and the Iron Cliffs Company, two of the oldest and largest concerns in the Marquette district, consolidated under a West Virginia charter, assuming the title of the Cleveland-Cliffs Iron Company, capitalized at \$5,000,000, of which \$4,500,000 was used to acquire the stocks of the two old companies, leaving \$500,000 for the purchase of new properties. The expected advantages are thus summarized in the circular to the stockholders:

Such an arrangement will insure the joint and harmonious working of the contiguous properties of the two constituent companies, and will inure to their advantage in many ways, chiefly in the saving of administrative expenses, in the elimination of competition, in advantage in purchasing supplies and in transactions with railroads and other transportation companies, a large corporation, in these days of consolidations,

having more power and influence than a small one. . . . From dividends on the stock in its treasury, and from its other earning and resources a surplus can be accumulated which will enable it to pay a regular quarterly dividend on its stock, thus giving it a stable value in the market, independent of any temporary depression in the iron trade.

The wisdom of these strong and conservative companies in thus pooling their resources was soon to be demonstrated; for during these days of the early nineties, though there were few signs of impending disaster, a storm was gathering over the Lake Superior ranges compared with which all previous ones were but summer breezes, and the companies were about to be subjected to a test before which all but the very strongest were to go down in ruin. Before taking up the story of those days it will be well for us to summarize briefly the characteristics of the period whose history we have just completed.

§ 20. First of all, it was a time of continuous and rapid improvement in the machinery and methods of iron and steel-making, such improvement bringing about a corresponding lowering of cost and price and consequent increase of consumption. The Bessemer steel industry sprang into being, coke displaced anthracite, and many of the furnaces of the Lehigh Valley blew out, yielding to the modern plant and advanced practice of the Pittsburg district.

The reduction of ore prices during this time was no less marked than that of iron values. After the sharp break of 1873 there was a continuous decline up to 1878, followed by a recovery culminating in a high figure of about \$9 for the boom years, as against the \$12 contract price of 1873. Then came another decline, which was helped on by the marketing of large amounts of cheaply-worked Gogebic ore, carrying down the price of the best specular ore to \$5.50, from which point even the boom of 1890 succeeded in rais-

ing it only a dollar. The period ends with the best ore once more worth about \$5.50 or less.

Such lowering of price was accompanied by a marvelous growth in production, which rose from less than 1,200,000 tons in 1873 to more than 9,000,000 in 1892. The inordinate demand of the iron-makers and steel manufacturers for the product of the Lake Superior mines made necessary the opening up of new sources of supply and the more extensive working of the older fields.

Three new ranges sent their first ore to market during the period under review and the number of shipping mines rose from 40 to almost 100, the total amount of capital required for the development of the region thus being vastly increased, and so keeping pace with the growth in capital of the large companies.

The greater production was brought about, however, not simply by increasing the number of mines, as was the case during the first twenty years of the history of the region, but by enlarging the output of the individual mine, the average shipment rising from 29,000 tons in 1873 to 105,000 in 1892. Such enlargement was due to a marked extension of underground work, and accordingly, despite the opening of new ranges, the mines deepened rapidly; in 1873 the deepest pit was not more than 75 feet; in 1892 the Champion mine was down 1,100 feet, the Lake Superior 900, the Aragon and Pewabic 500, and the Hamilton and Ludington considerably more than 1,000. The scale on which underground work was done during the latter part of this time may be judged from the fact that the Chapin in 1890 did more than eight miles of sinking and drifting. These twenty years indeed might almost be called the period of underground work; before 1873 the mines were all open quarries; after 1892, with the opening of the Mesabi, a new method of open-pit work was adopted which made even

more extensive demands on the company treasuries than did underground mining.

The fall of price, the enlarged scale and widening area of work, and the growing depth of the mines brought about a wonderful growth of capital, which was the all-important fact of this period. Contrast the open quarries of the early seventies, whose only equipment consisted of a few wheelbarrows and carts, some buckets and a swing derrick, with such mines as the Chapin or the Lake Superior in 1892, working at half a dozen different levels, hundreds of feet beneath the ground, lighted by electricity, equipped with power drills, with powerful hoists, with electric locomotives, which drew the ore cars over hundreds of yards of underground track, provided with pumps that cost tens of thousands of dollars and were capable of raising 3,000 gallons of water per minute over a distance of 1,500 feet, furnished with huge winding drums operated by great engines housed in permanent wooden and stone buildings—contrast them and it will appear how great was the increase during these twenty years in the amount of money required for successful operation of a Lake Superior mine. Place the crazy railroad of the earlier days with its puny engine and its 8-ton four-wheeled cars beside the solidly-built, well-ballasted structure of 1890, equipped with 20-ton cars and consolidation locomotives; or view the 700-ton vessel of 1873, with difficulty passing through the old 12-foot canal, and then look at the 3,000-ton freighter of twenty years later looming up above the lock walls of the new canal in which it safely rides on 16 feet of water—and the astonishing growth in transportation machinery made necessary by the development of the mining industry during this period will be evident.

The increase of capital in each mine and the consequent enlargement of output came coincidentally with the growth in

financial strength of the operating companies. The profits of good years were turned into capital and thus the financial ability of the better managed concerns grew more or less steadily. Note the development of such companies as the Lake Superior, the Cleveland, the Republic, and other Marquette corporations. And mark, too, the manner in which new companies came into being during the second decade of the period, the small Gogebic concerns, which in the early Lake Superior days might have attained strength by a process of slow growth, quickly perishing as a result of the new conditions of capitalistic competition, while those which had abundant financial backing, like the Minnesota Iron Company, quickly established themselves and made money rapidly. There is no more notable change during these twenty years than the supersession of the small company by the large one.

While the enlargement of the companies was thus giving greater importance to the operations of a few corporations, the development of new districts was preventing any marked reduction in the number of concerns at work.

The period may be denominated that of balanced growth, the increase in capital investment being offset by a remarkable expansion in the area of natural resources made available for the application of capital. On this account the general development during this time corresponds more closely with the commonplaces of the ordinary economic theory than does any other part of the history.

CHAPTER V

THE PERIOD OF LARGE CAPITAL: CENTRALIZATION

§ 1. The third period of the history extends roughly from the opening of the Mesabi range in 1892 to the formation of the United States Steel Corporation in 1901. These ten years are notable for open-pit mining, the entrance of the steel companies into the industry, the consequent increase of centralized capital and resulting division of the entire field among a few powerful interests. By the beginning of this period the industry had become so large and complex as to preclude detailed study in a short monograph; consequently the following chapter presents only a bare outline of those phenomena which illustrate the principles previously laid down.

During the years 1890-2 a radical change was preparing in the iron industry, and particularly in the Lake Superior mining business. Iron from Superior ores had always had a monopoly in Pittsburg and the Middle West. With Alabama, which had produced but 56,000 tons of iron in 1880, ten years later showing a product of 818,000 tons, sharp competition was springing up between North and South, and the northern furnaces were obliged to bring the price of foundry iron below \$13.

During the preceding years a remarkable reduction of cost had been taking place in certain of the northern works, enabling them to meet this competition. The great plants such as the Carnegie works, with their complete equipment, with their unhesitating adoption of improved methods,

with their reckless scrapping of all machinery not up to the highest standard of efficiency, carried the expense of making iron rapidly down and increased the production despite the decline in price. The average output of American blast-furnaces rose from 19,000 tons in 1887 to 38,000 in 1892 and to 52,000 in 1893. Clearly enough the competition of these large new furnaces, backed by abundant capital and operated in accordance with the most advanced practice, must have been rapidly driving out all but the best companies; the life of the marginal producer was hanging by a thread.

Meanwhile the stocks of ore left on the Lake Erie docks at the close of navigation were piling up rather ominously, rising from 1,000,000 tons in 1886 to almost 4,000,000 in 1890. The Superior mines had reduced their cost figure so notably during the preceding years that they were producing more ore than the market would take at the prevailing price.

As cheaper iron was a necessity and cheaper ore, because of the great improvements in mining and transportation, a possibility, there was bound to come a radical marking down in the price of the miners' product. That the fall would have been as violent as it actually was and would have proved as permanent if the Mesabi mines had not entered the market at just the wrong time for the luckless old ranges, is unlikely. To make clear the conditions prevailing during the middle nineties, therefore, the part played by the new range must be indicated.

§ 2. The Mesabi range has the most remarkable deposit of high-grade iron-ore known to-day. As already indicated, its reserves are supposed to be twice as great as those of all the old ranges combined, and the Lake Superior mines led the world even before the Mesabi was discovered.

It is not simply the marvelous extent of the deposits on

this range, however, which made its opening of such revolutionary importance, but even more the physical character and mode of occurrence of the ores, which made it possible to employ the steam-shovel in mining them. This machine had been used at the Colby mine by Captain Joseph Sellwood in 1884, but the great vertical depth of the Gogebic deposits made its employment there a mere temporary matter. On the Mesabi the comparative shallowness of the mines and the gentle pitch of the ore bodies have made it possible to use this remarkable mining system on a scale never before attempted, with a saving estimated by Mr. D. E. Woodbridge at no less than \$5,000,000 a year.

In steam-shovel mining as practiced on the Mesabi, the overburden, which consists of a varying thickness of glacial drift, is first stripped off by the steam-shovel, carried away in railroad cars and dumped in some convenient place. This stripping is no easy matter, as the drift is full of boulders, and is about as difficult to work as hardpan. The stripping done, a cut is made into the ore-body, a standard-gauge railroad track is laid down, and the cars are hauled directly out of the mine by the locomotive.

The steam-shovel used in the Mesabi mines differs from that employed in ordinary work only in being somewhat heavier and stronger. The dipper takes from four to six tons at a scoop and the record for the range was made at the Stevenson mine in 1904, when one of these machines handled 7,109 tons of ore in a day of ten hours, or at the rate of twelve tons a minute. It is an exceptionally good shovel crew, however, that can maintain an output of 3,000 tons a day for an entire season.

The ore is cut away in shelves or banks, a height of about twelve feet having been found most economical as a working face. As soon as one bank has been cut back a little, a second cut may be begun and a second track laid at

a lower level, the work thus proceeding in a series of two or three or even more terraces, all of which are cut back at the same time. The possibilities of output in such a case are limited only by the number of tracks and by the ability of the engines to handle the cars.

Consequently we find that some of the most difficult problems of Mesabi mining are those which have to do with trackage systems. The most varied and ingenious arrangements are employed, the tracks sometimes being laid in spirals, sometimes running directly through a deposit in roughly parallel lines. In general, it may be said that the steam-shovel can be used only where the ore-body is large and where the grade by which the tracks enter the mine is not more than three per cent; for the pulling ability of a locomotive on a two per cent grade is only one-eighth, and on a three per cent grade one-twelfth of what it can do on a level. As soon as the mine goes below the lowest adjoining land it becomes necessary to lengthen the approaches greatly, with a corresponding increase in cost.

The ore is loaded by the steam-shovel directly upon the railroad cars in which it goes to the lake, such cars carrying an average of 35 tons and the latest ones 50 tons.

The ores are so soft that little blasting is required; in some cases the steam-shovel takes them from the original bed in the same way that it handles earth in a railway cut, while in others small charges of powder are put in every few yards about nine or ten feet back from the working face in order to loosen the coherent masses.

The second main method of open-pit work on the Mesabi is the so-called milling system, which is employed where the steam-shovel method is impracticable on account of the difficulty of approaches or the depth of the deposit. Under this system the surface is stripped, a shaft is sunk at the edge of the ore, drifts are run out and raises put up to the

surface about 40 feet apart. The drifts and raises are secured by timbering, and tram-cars are run along the drifts to carry the ore to the shafts, where it is dumped into skips or cages, which carry it to the surface. The ore, loosened up by blasting, is pushed into the raises or mills, as they are called, and falls into the car at the bottom. Thus pits are formed about the raises, and when the ore is pretty well worked out the shaft is sunk deeper and the ore milled down to a lower level. By a proper placing of the mills almost no shoveling is required until the bottom of the deposit is reached.

Steam-shovel milling, so called, is simply a system of using a steam-shovel in a pit too deep to run in railroad tracks. The ore is worked with a steam-shovel and hoisted in a skip.

The cheapness of these methods as compared with underground work is evident at a glance. To quote Mr. Leith:

The cheapness of the open-pit shovel method as compared with underground mining is due to the large production possible, to the fact that timbering is not necessary, fewer men are required, lighting expense is less, all the ore can be moved (while in underground methods perhaps 10 per cent is lost), the ore can be better sorted, it has to be handled but once, and the hoisting is by locomotive on a grade rather than through a shaft. . . . In order that a deposit may be worked satisfactorily by the open-pit steam-shovel method it must have considerable horizontal extent as compared with its length in order to afford proper grade to the tracks. The deposit must be in a position to allow of an easy grade to the approach; this condition is met where a deposit is on a side slope. The thickness of the drift to be removed must not be too great, for otherwise the cost of stripping will run up the total cost of mining. There must be available ground with easy grades on which to deposit the dirt stripped off from the ore body. If there are capping

layers of poor or unsalable ores, these must be removed before the good ores can be mined. . . . Finally, unless the annual production is large, the interest on the preliminary investment for stripping, rolling stock, and so forth, necessary before a pound of ore can be moved runs the price of ore per ton up to a high figure.

On the other hand, when a deposit is opened up by an underground method there is little preliminary investment; no great mass of stripping has to be removed and disposed of; no layers of poor ore have to be removed before the good ore can be reached; the accessibility of all parts of the deposit does not depend on grade; the mine can be worked all the year round; and finally, the ore taken out while the mine is being opened goes to defray current expenses and to pay interest on the investment. Thus it is that while, where conditions allow it, open-cut mining costs less than half as much as underground mining, in many cases it is still advisable to use underground methods.

The milling method is a combination of the open-cut and underground method, and combines some of the advantages and disadvantages of both. It costs less than the underground methods of slicing and caving, because the timbering is less and all of the ore is saved, but it usually costs more than the open-cut steam-shovel method because of the shaft, drifts, uprisers, and the trammings and hoisting.¹

While it is difficult to make exact comparisons, it may

¹ Monograph 43, *U. S. Geol. Surv.*, pp. 283 *et seq.*

For descriptions of methods and comparative costs of mining on the Mesabi see in addition to the above: Denton, "Open-Pit Mining, with Special Reference to the Mesabi Range," in *Proceedings of the Lake Superior Mining Institute*, vol. iii, pp. 84-92; Denton, "Methods of Mining in Northern Minnesota," in *Transactions of the American Institute of Mining Engineers*, vol. xxvii, pp. 344 *et seq.*; Bailey, "Mining Methods on the Mesabi Range," *ibid.*, pp. 529-536; Winchell, *Geology of Minnesota*, vol. iv, pp. 581-616; D. E. Woodbridge, "The Mesabi Iron Ore Range," in *Engineering and Mining Journal*, January 12, 1905 *et seq.*

be said in passing that the timbering charge underground often exceeds the entire cost of steam-shovel mining, once the stripping has been removed. Such a fact gives some conception of the competition which the old ranges were called upon to meet under the calamitous price conditions prevailing after 1893.

§ 3. Though iron had long been known to exist on the Mesabi, the geologists, looking for deposits of hard ore similar to that on the Vermilion, had repeatedly condemned the range. Nevertheless certain iron men had faith in its possibilities, and to the perseverance of the Merritt brothers of Duluth credit must be given for the earliest development of this wonderful region.

On November 16, 1890, their explorer, Capt. J. A. Nichols, found the famous Mountain Iron mine, and the news of the discovery spread quickly, causing the wildest excitement. From December 1, 1890, to September 1, 1892, more than one hundred mining companies were formed in Minnesota with an aggregate capitalization of approximately \$200,000,000, and on the first day of March, 1892, eleven Mesabi companies, capitalized at \$21,500,000, filed incorporation papers.¹ By May 1 sub-leases had already been made calling for a minimum output of 1,550,000 tons yearly on royalties ranging from \$.30 to \$.65, advance royalties of \$270,000 having been paid. The largest contract was that of H. W. Oliver, who leased the Missabe Mountain mine on a \$.65 royalty with a guaranteed minimum of 400,000 tons, and made an advance payment of \$75,000.² During the season of 1893 the last of the five great groups of Mesabi mines was discovered and development was begun.

¹ Twentieth Annual Report *State Geologist of Minnesota*.

² *Ibid.*, p. 166.

The first shipment of ore was made in the latter part of 1892, when the range was reached by the Duluth, Missabe & Northern Railroad, constructed by the Merritts after they had made contracts with many of the mines so as to assure a paying tonnage. The next year the Minnesota Iron Company's Duluth and Iron Range road completed a fifteen-mile spur directly through the eastern half of the region. The story of the development of the mines is deferred to a later point.

§ 4. The disaster that overtook the American iron trade in 1893 and the following years is not revealed by any mere statement of the fall of prices and decrease of production, for it came close on the heels of a steady reduction of values which had carried the price of iron to the lowest point ever known. Contrast the course of prices with that before 1873. During 1871 no. 1 foundry pig iron at Philadelphia rose from an average price of \$30.50 in January to \$37.25 in December; it advanced further to \$53.87 in September, 1872, and fell off slowly to \$42.50 a year later; then it dropped \$10.00 in two months, after which it declined almost without interruption to \$16.50 in November, 1878. The iron-maker enjoyed very high prices in the years immediately preceding the panic.

Such was not the case before 1893. As has been pointed out, cost was being rapidly reduced in the best establishments, production was rising rapidly and prices were steadily going down. In the beginning of 1890 iron was worth \$20; the next year it stood at \$17.50 almost the whole year; during 1892 it went down to \$15; and 1893 saw a further reduction to \$13.75.¹ Bessemer pig, which was worth \$24.50 in January, 1889, was quoted at \$10.90 and \$11 in December, 1893.

¹For monthly prices of pig iron since 1860 see report *American Iron and Steel Association* for 1903, p. 85.

Following this steady decline in prices came the financial panic of 1893. The effects of the tightness in the money market began to show early in the year; in April the Pennsylvania Steel Company suspended payments, though the auditor's report shows assets \$3,000,000 in excess of liabilities. The first of June saw a financial flurry in Chicago. Pig-iron makers began to offer their product at bargain prices in order to get money in hand; some of the smaller mining companies were reported as being unable to ship ore simply because they could not get money to pay freight. The situation grew worse and worse, and as general business came more and more nearly to a standstill the furnaces one after another blew out. At the beginning of the year 253 furnaces were in blast, at the end, 137; during the first half of the year 2,000,000 tons of Bessemer steel were produced, during the second half, 1,000,000; in the first six months the output of pig iron was 4,500,000 tons, during the last six, 2,500,000. Business men simply could not get money for their projects and the iron and steel-makers were without a market.

The year 1894 opened with the trade in the depths of depression, but by midsummer it had descended to yet lower depths. Production and prices were at their lowest level, and a gradual recovery culminated in a speculative boom during the latter half of 1895, carrying the year's production of pig iron to the highest point ever known.

The growth of the large producer was more notable than the recovery in production. Frederic Hobart says:

The results of the year show an increased tendency to the centralization of the trade in a few districts; a growth in the business and strength in the larger concerns at the expense of the smaller producers; and they emphasize the fact that under stress of modern competition and the improvement in processes

it is only the largest and best equipped plants that can expect to prosper and to hold their position in this trade.¹

The next two years were little more than a repetition of the preceding three. Though the number of furnaces in blast declined from 240 in January, 1896, to 131 in October, production was enough above consumption to weaken prices considerably, and for the first time southern furnacemen found it profitable to ship pig iron to England. The low prices led to a multiplication of pools and combines, notable among which were the wire nail and steel billet combinations. The high prices maintained by the latter during the few months when it was really effective emphasized the advantage to the manufacturer of finished goods of having his own supply of raw material, and in this way encouraged the movement already begun by the steel companies for getting control of the mines. The dissolution of the pools early in 1897 caused free competition and low prices which, however, were met by increasing consumption. When the rail pool broke up in February the price fell from \$25 to \$15 at the mill. Bessemer pig iron, which was worth \$10.50 in January, sold at \$9.50 in May, recovering the loss by the end of the year.

No further facts or figures will be adduced to show the condition of trade during these five years; ruinous prices, contracted credit, limited consumption, sharp competition, ineffectual attempts at combination to hold up prices, failure of the weak companies and growth of the strong ones—such were the conditions in the trade at large, and they led to a most remarkable overturning and readjustment in the mining industry.

§ 5. At the opening of 1893 all was uncertainty in the ore market; no one knew what the Mesabi producers could

¹ *The Mineral Industry*, 1895, p. 389.

do, though it was estimated that they could mine ore for \$.25; adding \$.50 royalty, \$2.00 freight and \$.25 selling expenses, all liberal allowances, this would enable the Mesabi men to put ore into Cleveland at \$3. Small wonder that the old ranges were panic-stricken, when season prices for 1892, the lowest on record, had been \$5.50 for hard ores and \$4.50 for Gogebic Bessemer hematites. Prices went all to pieces and it became almost impossible to sell ore even at figures from \$.50 to \$1.50 below those of the previous year.

Mesabi prices were even lower than old range. Owing to the softness of the new ores they packed in the furnace, causing dangerous explosions, and it was several years before the furnace-men learned to use more than a small proportion of them in their mixtures.

§ 6. Low prices and steam-shovel work necessitated heavy capital and operations on a large scale; without them success was impossible.

The Biwabik mine will serve as an illustration. Here was an ore body containing more than 20,000,000 tons, owned by wealthy lumbermen. They leased it at a royalty of \$.25 to the Biwabik Iron Company, which sub-leased to the Biwabik Ore Company on a \$.50 royalty with a guaranteed minimum of 300,000 tons a year and a guarantee to mine out all the ore in twenty years. Careful explorations were made, the steam-shovel method was adopted, an electric-light plant, locomotives and tracks were provided, and \$90,000 was spent in stripping, showing up 25,000,000 tons of ore of the very highest grade, running above 65 per cent in iron and low in phosphorus. Every yard of stripping uncovered three or more yards of ore and the cost of stripping was not far from \$.05 per ton of ore. The winter of 1892-3 was unexpectedly severe and the panic upset all financial calculations. The company, though recognizing the

great value of its lease, could not raise money to continue, so it threw up its contract after taking out about 150,000 tons of ore. The next year the Biwabik Bessemer Company took hold, but heavy stripping and lack of capital forced it into bankruptcy. The Lake Superior Consolidated Mines, the Rockefeller company, meanwhile had purchased the first lease on a \$.30 basis and stood ready to snatch up the mine when the sub-lessees let go.¹

The same thing happened at the Berringer mine, leased to the Duluth Ore Company on a \$.50 royalty and a 100,000 ton minimum. Though its 1903 product could not be sold, the royalty had to be paid and the company was obliged to abandon to the Consolidated the mine and all it had put into it.

The story of nearly all the small companies on the Mesabi is suggested by these examples. With high royalty and large guaranteed output any company which took a lease was saddled with a large annual payment (sometimes \$100,000 or more), which had to be met whether a ton of ore was shipped or not. An advance royalty of as much as \$25,000 had often to be paid and heavy expense incurred for equipment and stripping before a cent could be returned by the sale of ore. Add to this the fact that the difficulties of the work were at first greatly underestimated, that steam shovels in the early days often gave out, causing heavy expense for repairs and loss of time, that it was very hard to find a market for ore, and that when it was found prices were low in the extreme—and it will be seen that any company operating on a narrow margin, or trusting to large immediate returns to make good a deficiency in its treasury, was bound to fail. The early years of Mesabi history are filled with the wreck of companies which attempted the impossible task

¹ *Proceedings of the Lake Superior Mining Institute*, vol. iii, pp. 23-25.

of mining without adequate financial support. That such backing was the main thing necessary during this time is shown by the history of the three great companies which so quickly came into possession of almost the entire range, and the story of the Lake Superior Consolidated Iron Mines, the Minnesota Iron Company and the Oliver Iron Mining Company will therefore next be related.

§ 7. The entrance of the Rockefeller party on the Mesabi range is full of dramatic interest. We shall not discuss the morality of their transactions nor enter into the details, which are unimportant for our purpose. It is enough to say that the Merritts, the pioneers of the range, in order to carry out plans for developing their mining properties and the Duluth, Missabe & Northern Railroad, borrowed money from the Standard Oil magnate, and when the hard times of 1893 made it impossible for the Merritts to meet their obligations, Mr. Rockefeller foreclosed his mortgages and gathered in at one swoop the entire Merritt holdings. The cost to the Rockefellers of these properties, including the Mountain Iron and other mines, which contained at least 75,000,000 tons of ore, and the railroad, which had tonnage contracts worth millions of dollars, was probably not more than \$1,500,000. By an additional expenditure of less than \$2,500,000, paid out during the depth of the depression to mine-owners who had to realize on their properties, almost 100,000,000 tons more were gathered in, and by the end of 1894 the Rockefeller party, by virtue of the possession of a few paltry millions, had come to own the western half of the marvelous Mesabi treasure-house.

The advantage which the Rockefeller concern secured from its unlimited capital is thus suggested by a writer in the *Iron Age*:

During the recent period of depression in trade and of terrible stress in the iron and associated markets this company have not faltered in the steady pursuit of their plans for acquiring mineral rights and for strengthening the position of their transportation interests. They are said to have been able to secure many million tons of ore at prices so low that they seem ridiculous.

The entire Rockefeller holdings were put into the Lake Superior Consolidated Iron Mines and capitalized at \$30,000,000, of which capital \$28,000,000 was issued. Neither the Consolidated nor any of its constituent concerns had a penny of debt, excepting the bonds of the railroad. By 1899 the company owned in fee the Mountain Iron, Etna, Pillsbury, Lone Jack, Duluth, and other mines; it leased among others the great deposits of the Lake Superior Iron Company at Hibbing, the Day and Sellers, Adams, Ohio, Oliver, and Biwabik mines; and by its ownership of the railroad and its control of the Bessemer Steamship Company, which had a fleet of 22 large vessels, it delivered its ore in Cleveland without paying a cent of profit to any one.¹

§ 8. The second great holder of Mesabi properties was the Minnesota Iron Company. There was a time when it might have acquired all the Merritts' holdings for a little more than \$1,000,000, but it allowed them to pass into other hands and contented itself with buying mines on the eastern half of the range to which its railroad extended. Like the Rockefeller corporation, it bought the property of embarrassed companies cheap, and also carried on extensive and systematic exploration of swamp and timber land, as a result buying the great Canton mine, among others, for \$1.25 an acre. During one week in April, 1893, it ac-

¹ See "The Rockefeller Ore Interests," in *Iron Age*, May 11, 1899; Winchell, "The Iron Ranges of Minnesota," in *Proceedings of Lake Superior Mining Institute*, vol. iii, pp. 15-32.

quired 7,600 acres of land, and in 1895 it was supposed to have expended something more than \$1,000,000 in getting control of 40,000,000 tons of ore, having at that time over 13,000 acres of land under option. By this aggressive policy of exploration and purchase the company was able to constitute itself a good second to the Consolidated.¹

§ 9. It should not be supposed that capital alone accounts for the wonderful success of these companies in getting possession so rapidly of the best mines on the range. That success was due also to the skill and judgment of their explorers and superintendents, the promptness of their directing heads in selecting promising properties, and the craftiness of some of their managers in taking advantage of the troubles of their rivals. That the buying of Mesabi lands in those days was not all profit is shown by the experience of the Duluth & Winnipeg Railroad, which spent \$750,000 in buying land that did not contain a ton of ore, with bankruptcy and the transfer of the road to other hands as a result. The great companies did not altogether escape mistakes of this kind, but their wealth prevented such blunders from proving fatal, while the lesser concerns even when they discovered valuable properties were generally unable to hold them during the years of depression; if they tried to work them, their capital gave out and they had to throw up their leases or go bankrupt; if they desired to sub-lease, the giants were able to offer them better terms than any one else. The result was a concentration as inevitable as unexampled.

§ 10. To Henry W. Oliver, of Pittsburg, must be given credit for first applying consistently the principle that economical operation of steel works requires the ownership of ore and coke supplies. Though furnace companies had

¹ See Winchell, *op. cit.*

owned Lake Superior mines almost from the start,¹ it was in order to share the large profits of mining rather than to secure an advantage for the furnaces. Mr. Oliver saw the necessity of the steel-maker's having an independent supply of raw material, but he found that the acquisition of the best ore supplies involved outlays so large as to lie beyond the powers of any but the largest concerns, and he therefore welcomed Mr. Frick's proposition that the Carnegie Company should receive one-half the stock of the Oliver Iron Mining Company in return for a loan of \$500,000, secured by a mortgage on the mines, to be spent in development work. Mr. Carnegie opposed the arrangement in a letter dated August 29, 1892: "Oliver's ore bargain is just like him—nothing in it. If there is any department of business which offers no inducement, it is ore. It never has been very profitable, and the Massaba is not the last great deposit that Lake Superior is to reveal."² Despite his objection the bargain was struck.

Mr. Carnegie's early opposition to mine purchase was based on the great uncertainty concerning possible new discoveries. He thought it better to let others take the risks of the ore-business while his company devoted itself to building up a perfect mechanical equipment and an unequaled organization.

During the time when the Consolidated and the Minnesota Iron Company were gathering in for almost nothing the matchless properties of the Mesabi, Mr. Oliver was busy demonstrating to his partner the advantage of an adequate and independent source of ore supply, and as a result of the slowness with which the Carnegie Company adopted his view, they paid a much higher price for their ore hold-

¹ *Vide*, p. 51, *supra*.

² Bridge, *The Inside History of the Carnegie Steel Company* (New York, 1903), p. 259.

ings than they would otherwise have done. Once the demonstration was complete, they took up the policy with a rapidity and thoroughness which brought them at once into the first rank of ore-holding companies.

§ 11. The first venture of the Oliver Company was the leasing of the Missabe Mountain mine in 1892, on a royalty of \$.65 and a guarantee of 400,000 tons a year, with an advance payment of \$75,000. Such an arrangement would have bankrupted any smaller concern under the conditions prevailing after 1893, but with Carnegie money to help in the day of trouble and Carnegie and Oliver furnaces to furnish a market for ore, the company passed through the depression without any inconvenience, and the mine, instead of falling into the hands of the Standard Oil king after bankrupting its owners, as so many of the others did, proved a source of vast profit to the lessees.

Opened up for steam-shovel operation, the mine was from the first worked with a view to tremendous output. Instead of stopping, like the other companies, with the first chill in the market, the Oliver went straight forward stripping, laying tracks and providing equipment, assured that there would be a market for the product and feeling no anxiety as to the immediate financial returns. In consequence this mine was the marvel of the Mesabi during the troublous times of the middle nineties. In the latter half of 1896, for example, when depression overtook the whole trade, when furnaces were blowing out and mines closing down, when the entire Mesabi range, with usual employment for 6,500 men, was working less than 700, we find the Oliver shipping full speed, working day and night, and making a record for the year of 810,000 tons.

The cost of mining this vast output was a matter for widespread speculation at the time, and the estimate of the most competent authorities placed it not far from \$.10 a

ton, including that part of the stripping properly chargeable against the season's product.¹

The ore of the Oliver mine could not be used alone for a furnace mixture. During the early part of the year, therefore, the Carnegie Company had made large purchases of high-grade Bessemer ores, and by using these to "sweeten" the Oliver product they secured at a low price about all the material needed for their entire winter's production of Bessemer pig, thus disappointing the hopes of sellers that they would be in the market for ore later in the season. The singular advantage which the Oliver mine had in its connection with the Carnegie furnaces and the reciprocal advantage to the furnaces in affiliation with the mine were evident enough.

§ 12. The lesson of this experience was not lost, and the Carnegie Company hastened to secure themselves a competent ore supply so long as the Lake Superior mines should hold out. This their enormous capital enabled them to do through an alliance with the Consolidated in the famous Carnegie-Oliver-Rockefeller deal which startled the ore trade out of its senses at the end of the season of 1896.

The Carnegie-Oliver party leased the Mountain Iron and Rathbun mine from the Consolidated on a royalty of \$.25. They guaranteed a minimum output of 600,000 tons a year from this mine, and an equal amount from the Oliver, all to be carried over the Rockefeller railroad and by the Rockefeller boats, at \$.80 for the land and the going rate for the water haul. At that time the Mountain Iron mine was the only Bessemer property on the Mesabi which could be worked by steam-shovel. The Carnegie Company thus secured a guaranteed supply of high-grade ore at a low royalty, while the Rockefeller interests obtained a guaranteed tonnage of 1,200,000 tons for their railroad and steam-

¹ See *Iron Age*, vol. lviii, p. 776.

ship lines. Rockefeller kept out of steel manufacture and Carnegie temporarily out of transportation.¹

With ore thus brought to Conneaut cheaper than other concerns could secure it, with their own railroad under construction to haul it to Pittsburg, with furnaces and steel mills to convert it at lowest cost into finished form, the Carnegie Company possessed a position of vantage before which their rivals might well quake. If there is one thing evident, it is that the mere bigness of the Carnegie interests enabled them to secure this remarkable contract from the Rockefeller party, who would otherwise have had no motive for giving up control of their most valuable mine.

§ 13. The moment this bargain became known, it threw the ore trade into a panic. As Mr. Oliver put it, "We simply knocked the price of ore from \$4 down to say \$2.50 a ton. Now let us take advantage of our action before a season of good times gives the ore-producers strength and opportunity to get together by combination."²

Such advantage the Carnegie Company were not slow in taking. They reached out after the best available Bessemer properties, not only on the Mesabi, but on the old ranges as well. Of these the Norrie and Tilden on the Gogebic and the Pioneer on the Vermilion range were of special importance. The following quotations from a letter sent by Mr. Oliver to Mr. Frick on July 27, 1897, will help to make the situation clear:

I mail you my specific reports on the Norrie, Tilden and Pioneer mines.

. . . . I claim that we could produce and deliver our ore to

¹ For details of this transaction see Glier, "Zur neuesten Entwicklung der Amerikanischen Eisenindustrie," in Schmoller's *Jahrbuch* for 1903; "The Carnegie-Rockefeller Deal," in the *Iron Age*, Feb. 18, 1897.

² Bridge, *Inside History of the Carnegie Steel Company*, p. 265.

Lake Erie ports 20 to 30 cents per ton cheaper than it can be done by those now in control of the mines we seek. Our saving would be in steady and more regular mining, in avoiding a line of high-salaried officers, in procuring lower lake freights, and in saving the Cleveland commission of 10 cents per ton. I am satisfied that the economies that we will practice in the lines above indicated will be fully equivalent, in the future, to any royalties we may pay. The Carnegie furnaces and the Oliver furnaces will require about four million tons of ore per annum. Our minimum, under my proposition, would stand as follows:

Mesaba	1,200,000 tons.
Norrie	700,000 "
Tilden	400,000 "
Pioneer	500,000 "
Total	<u>2,800,000 tons.</u>

On the Gogebic Range the mines I have selected comprise over 80 per cent of developed ore or "ore in sight." . . . They are the only mines on the range that can mine ore at present prices and make money. . . .

If there be not large quantities of ore in the properties we have under consideration, then there are no large deposits of Bessemer ore yet known, outside of the Mesaba Range and the Chapin and Minnesota Iron Company's properties. . . .

. . . The possession of a large body of ore in the Gogebic Range will strengthen our position in holding the Rockefeller people down to low freight rates from the Mesaba Range.

I am not ignoring the strong position we hold on the Mesaba Range. With two exceptions, we possess the only steam-shovel mines, and the low cost of this ore is extremely gratifying. . . . Although we are mining it at present at less than five cents a ton for labor, we must look to the future, when we will have to go deeper, pump water, and lift the ore. We should rather prolong the period of cheap steam-shovel mining, take in the other Range properties I suggest for mixture, and by

working one Range against the other, keep down the cost of freights.¹

The securing of these three valuable properties was no easy task, the Norrie, for example, being owned by more than three hundred stockholders. It is possible that their willingness to sell was due in part to the fact that the mine had been working with rather inadequate equipment; certainly the disastrous prices and limited demand of the years just preceding the offer had much to do with the final result. At any rate, by the expenditure of a sum reported to be about \$2,000,000 the mine was finally bought in the latter part of 1897, and the Tilden was acquired at the same time on a fifty-year lease at a royalty of \$.50. The next year the company got the Pioneer on practically the same terms as the Tilden.

Considerable changes were made at both the Norrie and Tilden in methods of work and the cost of production was materially reduced. The large scale of operations made it possible to attempt economies impracticable in smaller mines; thus Dr. Hulst, superintendent of the Oliver Company, was trying in 1898 the experiment of drying ore at the mines, estimating that the company were shipping in a year 90,000 tons excess moisture from the Norrie alone. The Carnegie Company began securing ore from \$.30 to \$.80 a ton cheaper than their competitors.²

§ 14. By the successful closing of the deals above mentioned the Carnegie Company had obtained control of the very best Bessemer properties at that time known, excepting only the Chapin and the Minnesota Iron Company's mines. They accomplished this result at a compar-

¹ For the full text of this remarkable letter see Bridge, *op. cit.*, pp. 261-266.

² *Iron Age*, August 18, 1898.

atively high cost, if we contrast their acquisitions with those of the Consolidated and the Minnesota Company—a result due to the fact that they were somewhat later in entering definitely upon the policy of mine control and that their action was governed by their needs as steel-makers rather than as mine-owners.

Their fundamental idea was to secure control by long-time lease of properties which by reason of large ore bodies and cheap mining facilities could furnish large amounts at low cost; and in the second place, to secure all grades of ore needed for the economical production of pig-iron. In pursuit of this policy they paid whatever they were obliged to for such properties as they wanted; that they came off as well as they did was due to the hard times which had made mining unprofitable, and to the large capital of the company which enabled them to incur any obligations which they found desirable.¹

It should be noted, further, that the Carnegie Company did not at first make independent transportation arrangements, but relied on the magnitude of their business to obtain them favorable rates from existing agencies. The Rockefeller contract on the Mesabi railroad will be recalled; a \$.40 rate from the Gogebic mines to Ashland was secured; the Carnegie tonnage from the Vermilion range was so large as to warrant building an additional road, if necessary, so they did not fear exorbitant rates from that district. On the lakes they depended on their contract with the Rockefeller fleet and on independent vessel charters. From Conneaut to Pittsburg they had their own road under construction. In transportation, as in mine ownership, the action of the Carnegie Company was at first characterized by a caution which put them for the time being at a disad-

¹For sketch of the Carnegie acquisitions see "The Carnegie-Oliver Ore Interests," in the *Iron Age* for Sept. 15, 1898.

vantage; but when they did undertake the work they carried it through with unequalled decision and thoroughness.

The division of the Mesabi field among the three great companies during the years of depression has now been hastily sketched. The force which brought about the rapid concentration of control was the possession by these three corporations of enormous available capital, which enabled them not only to buy out their embarrassed rivals for a fraction of what their property was worth, but to operate that property in the most economical manner, quite irrespective of any temporary market conditions or financial considerations.

§ 15. In order to complete the picture of the dark years the condition of the old ranges must be briefly described. Of course the primary fact was the great reduction of prices and the necessity for getting cost down correspondingly. Marquette specular Bessemer ore was contracted for the season of 1893 at \$4.50, \$1 below the lowest price ever known up to that time. In 1894 the price took a further drop to \$3.35; the next year it was lower still; in the beginning of 1896 it recovered to \$4.50, only to plunge below \$3 in 1897; and it was not until 1900 that ore was again contracted above \$3.50.

In the light of prices such as these it is not difficult to imagine what was occurring in the mines. With the first breath of the panic, some of them closed down never to be re-opened, others to wait until they should fall into the hands of stronger owners.

Wages dropped from an average of \$2 a day in 1892 to \$1.35 in 1894, and men were turned off by the thousand. On the Vermilion range, where almost 2,000 men were usually employed, there were but 250 at work in the middle of 1896; the Gogebic, normally employing 10,000, had at the same time but 800 in the mines, and there were nearly

a thousand men at the towns of that range who could neither get work nor get away, though all who could scrape together money enough had gone to try their luck in the copper camps or elsewhere. Not a business man on the range, it was said, had made more than bare expenses in three years, the miners all being heavily in debt. The Marquette and the Menominee were not quite so bad off, yet we learn that a firm at Norway ordinarily doing a business of \$2,500 a month, one day in February, 1897, took in only \$1.50, and another almost as large had but \$.25 trade in an entire forenoon.¹

In the mines expenses were cut to the bone, and the cost of mining on the old ranges in 1894 was from \$.50 to \$1.20 for soft ore, and ran as high as \$1.50 for hard. This, however, was less than the normal cost of production, for it included no dead work. During the fat years preceding 1892 the mines had been developed well in advance of immediate needs; consequently after the panic, dead work was largely suspended for some time and thus the cost was cut for a year or two, the mines practically living on their capital. By the end of 1894 the reserve tonnage previously opened up was pretty well exhausted and development work had to begin again.

Mining methods were changed where practicable, economies being effected by the use of caving systems, which lessened the expense of timbering; by catching the ore in chutes instead of shoveling; by adopting mechanical and mule haulage, which allowed ore to be trammed longer distances and made fewer shafts necessary; by employing skips instead of cages for hoisting; by using the steam-shovel in loading from stock piles, which multiplied the efficiency of labor sixfold and reduced the cost of loading

¹ *Iron Age*, Feb. 11, 1897; see also *The Mineral Industry* for 1894.

fifty per cent; by adjusting the duties of every position and dispensing with every superfluous man. "The first blow of the panic was met by a stoppage of exploring and development work and severe reductions in wages, thereafter by rigorous economy, the strictest attention to details and the overhauling of methods, and, as the outlook brightened, and wages again advanced, by labor-saving plans and the increase of outputs."¹

§ 16. Let us examine the detailed cost in 1894, as given by Mr. J. Parke Channing.² It is divided into six parts:

(1) Mining. This includes exploration, stripping, development, equipment, and exploitation of ore at the mine. It should cover all expense necessary to put the ore into the cars of the railroad company and is cut largely in times of depression. During 1894 mining costs ran about as follows: On the Marquette, \$.75 to \$1; ³ on the Menominee, \$.50 to \$1; on the Gogebic, \$.60 to \$.90; on the Vermilion, \$.60 to \$1.20.

(2) Royalty. This varied from \$.20 to \$.50. During the years of depression fee-holders had to submit to a reduction of royalty or else sell out cheap; not a few chose the latter alternative.

(3) Railroad freights, including loading into the vessel. These rates on the Michigan ranges had been cut 20 per cent for 1894, running at \$.32 from the mines to Marquette and \$.52 from mine to port on the Menominee and Gogebic ranges. On the Minnesota road no concessions were made. The rate remained at \$1 from Ely and \$.80 from Tower to Two Harbors.

¹ William Kelly, "Presidential Address," in *Proceedings of the Lake Superior Mining Institute*, vol. vi, pp. 13-23.

² *The Mineral Industry for 1894*, pp. 375-402.

³ This affords an interesting contrast with Major Brooks' \$2.64 in 1870, and shows clearly the power of capital to counteract the law of diminishing returns.

(4) Lake freights, including trimming, and unloading at Lake Erie ports. During 1894 the season contract rate from Duluth, Two Harbors, Ashland and Marquette was \$.80 and from Escanaba \$.50; from the head of the lake wild rates averaged \$.78, from Marquette \$.60, from Escanaba \$.47. This gives the total cost of transportation from the Vermilion range as about \$1.80, from the Gogebic \$1.30, from the Marquette and Menominee about \$1.

(5) Commissions to ore agents. In 1894 these still stood at \$.10 a ton, the same figure as during preceding years, when prices were nearly twice as high.

(6) General expenses and insurance, covering marine insurance on the ore, analyses, sampling, discount on bills, and the expenses of the home office, the total running about \$.05 a ton.

Adding all items we get a total for the Marquette of about \$2 to \$2.75, for the Menominee \$1.35 to \$2.75, for the Gogebic \$2.25 to \$2.85, and for the Vermilion \$3 to \$3.65.¹

§ 17. If these costs be compared with the prices realized for ore from 1894 to 1897 it will be seen that except in specially favored cases the companies were making no profit; as a result the number of old range mines reporting shipments, which was 85 in 1892, decreased to 49 in 1898. Some of the wealthy companies which continued operations lost as much as \$300,000 each in 1893-4, without counting the exhaustion of their ore reserves. The stock of the Pittsburgh and Lake Angeline Company went down from \$175 to \$65, the Cleveland-Cliffs from \$100 to \$25, the Minnesota from \$90 to \$40, the Lake Superior from \$65 to \$20, while

¹ The railroad charge of \$1 and \$.80 from the Vermilion range included a large profit, which went to the Minnesota Iron Company through their ownership of the railroad. The cost of their ore should therefore be reduced below the figures given.

the securities of poorer concerns were worth practically nothing, and with the Mesabi specter in the background there seemed little prospect of improvement.

Many companies went bankrupt and the properties of others passed into stronger hands. The extensive holdings of the Schlesinger syndicate on the old ranges proved too great a load for them to carry and their mines were distributed among more powerful interests, the Chapin, the best of all, going to M. A. Hanna and Co. The greatest concerns were so busy acquiring Mesabi properties that they did not extend their operations widely on the old ranges, though they made a beginning.

The operations of the ore pools are necessarily dismissed with a mere mention. Brought into being by the grinding competition of these years, they made a brave effort to maintain prices. But no combination could long keep up the value of ore under the conditions which prevailed in the middle nineties, and though the pools, with many vicissitudes, maintained an existence up to 1904 their operations did little if anything to check the process of ruin and concentration during the evil days upon which the trade had fallen.

§ 18. It would be easy to show how enormously the capital invested in individual mines increased during the years under review, but as this process was perhaps sufficiently emphasized in the discussion of the preceding period it is here dismissed with the mere statement that the enlarged scale of operations and the more expensive machinery used in the old range mines and the adoption of the open-pit method on the Mesabi made only more imperative the demand for larger and larger capital.

The growth of output per mine was something marvelous. In 1892 for the first time the average shipment passed 100,000 tons; during the next four years, before

the adjustment to new conditions was made, it did not greatly increase; but in 1897 it jumped to 154,000 tons and in 1898 was 203,000. This enlargement of output was one of the most potent forces in reducing cost to bring it within the limits imposed by the new price.

§ 19. The increase of capital in transportation and the improvements there made were even more astonishing than the changes in the mines. It will be remembered that the 16-foot canal was outgrown almost before the improvement was completed in 1883. Both the United States and the Canadian government began the construction of 20-foot waterways, and the Canadian locks were thrown open in 1895. The next year the great work undertaken by our own engineers was completed, a lock 800 feet long and 100 feet wide, with 21 feet of water over the miter-sills, being finished at an expense of about \$3,500,000. At the same time that the canal was under construction, work was being vigorously pushed on the Hay Lake channel, which shortened the passage from the canal to Lake Huron by eleven miles and also made possible night navigation, a thing never attempted by the old Lake George route. This improvement cost an added \$2,000,000 and was opened to commerce in an unfinished state in 1894.

The result of deepening the canal was immediately apparent in the size of the vessels built. The rapid growth noted during the last years of the preceding decade was more than matched by the change now brought about, whose details, though of the liveliest interest, it is unnecessary for our purpose to give. Their effect is sufficiently indicated by the remark of a prominent vessel owner who said in 1897 that it would be safe to trade anything of less than 2,500 tons capacity for a ham sandwich and throw away the ham.

The Lake Carriers' Association at a meeting held in Janu-

the 1897, decided to reduce expenses in every possible way to meet impending conditions. Although many vessels were being driven out of business because of inability to handle freight in competition with the big steamers, no attempt was made at a combination to keep up rates. The vesselmen wisely accepted conditions as they existed and tried to adapt themselves to them, instead of fighting against the inevitable.

The enlargement of the lake fleet during the years of depression was accomplished mainly by the powerful concerns because they alone could raise the money needed for construction. The Bessemer Steamship Company, the marine branch of the Rockefeller organization, kept growing by continual additions until at the beginning of 1900 it had 28 vessels with a carrying capacity of 3,500,000 tons in the seven months' season. The Minnesota Iron Company's fleet included 15 steamers and barges; the Cleveland-Cliffs controlled 10 and the Lake Superior Iron Company 6. Of course there was also large increase on the part of the independent vessel interests, but the whole tendency was toward closer affiliation of vesselmen with mining concerns, and the control of both by the steel companies.

Even more remarkable than the increase in the size and number of vessels was the evolution of improved machinery for the rapid handling of the product at the docks. Such machinery was largely used during the period of hard times, but it has been installed with special rapidity in the years of prosperity since 1898. The increased speed of handling only cheapened by so much the cost of moving ore and increased the grip of the great corporations which more and more controlled the transportation lines and docks. In this as in every other direction the years of depression helped on the process of centralization.

§ 20. The period beginning with 1898 brought marvel-

ous growth and prosperity to the American iron and steel trade, the course of events up to 1902 furnishing an interesting parallel to the development that occurred two decades earlier. Beginning with an upward turn in the latter part of 1897, demand steadily and rapidly increased during 1898, and 1899 saw no halt in the upward course of consumption and prices. At the end of 1899 nine of the large steel interests had under construction 22 furnaces, with an aggregate yearly capacity of more than 3,000,000 tons. All grades of pig-iron and finished steel sold in December for more than twice the prices quoted in January.

The year 1900 saw a sharp break in prices and a reduction in the number of furnaces in blast which caused the year's product to vary little from that of 1899, but with the opening of the next season demand again rose and carried the production up to almost 18,000,000 tons in 1902, a figure which was surpassed in 1903, despite the heavy decline in values marking the latter half of that year.

The epidemic of industrial combination which marked this period of prosperity needs no description. A series of consolidations in the steel industry such as the world had never seen, culminated in 1901 in the formation of the Steel Corporation. Our only interest in these progressively enlarging combinations lies in their massing the capital available for mining in larger and yet larger units. Thus the portion of the field which the individual company was economically able to work grew at a tremendous rate, until the Steel Corporation in 1901 had come to control more than half the output and a yet greater proportion of the reserve tonnage.

§ 21. It might naturally be thought that a time of prosperity would call into being large numbers of new producers, and such was to a certain extent the case; but the great companies and particularly the Oliver were so wide

awake in the search for new properties and were able to offer such great inducements that the small holder generally found it more profitable to sell or lease his property than to undertake to work it himself.

By 1899 the Oliver Company was no longer confining its attention to high grade Bessemers, but was taking high and low grades, high-silicon and high-phosphorus ores, in fact almost anything of reasonable quality. With all this it was not buying wildly, and in nearly all cases its ore purchases proved to be good bargains. As to developed mines, it did not cease its activity with the acquisition of the Pioneer in 1898; but after buying the Lake Superior, the leading Marquette property, with a fleet of six vessels, it kept extending its holdings both on the Mesabi and on the old ranges as fast as it was able to get hold of desirable properties. Such purchases of course were practically on account of the Carnegie Company, which by this time owned five-sixths of the stock of the Oliver concern. The other steel companies, following the lead of the Carnegie, were making desperate efforts to provide themselves with adequate ore supplies.

§ 22. With the upward turn of prices the Carnegie Company began to pay the penalty of its neglect to provide transportation facilities. To get its Vermilion ore to the lake cost \$1, and to bring that from the Mesabi, \$.80. Believing that it could be carried for less than half that amount, the Oliver Company laid plans for a railroad; and had it not been for the amalgamation which finally united the Carnegie, Consolidated and Minnesota interests, the Carnegie Company would by this time have forced concessions from the railroads of its rivals, or else would have established rail connection from both the Vermilion and the Mesabi ranges.¹

¹See *Iron Age*, Aug. 18, 1898, and Sept. 7, 1899.

On the lakes, matters were more serious than on land. Bound by a contract to ship 1,200,000 tons by the Bessemer Steamship Company at the going rate and dependent on outside vessel owners for its remaining tonnage, the Carnegie Company was bound to incur heavy loss by any large rise in lake freights.

According to common report, Mr. Rockefeller, in 1899, offered all his mines, railroads and steamships to the Carnegie Company for \$50,000,000. His offer was refused, whereupon he cornered the vessel market for 1900. He bought the whaleback fleet of about 30 boats for \$3,000,000, and chartered a dozen other large steel ships, giving the Bessemer Steamship Company control of 70 of the largest and most modern vessels on the lakes. The Carnegie Company, defeated in their efforts to get the whalebacks, tried to buy the Mitchell boats of Buffalo, and Rockefeller checkmated them by leasing the whole fleet for the season at the high rate of \$1.25 a ton. Thus defeated by the resourcefulness of their great adversary nothing was left for the Carnegie Company but to accept his terms; consequently the contract rate for 1900 was fixed at \$1.25 from the head of the lakes.

The Carnegie Company were too shrewd to be caught a second time, however, and so formed the Pittsburg Steamship Company, covering the financial requirements by a paid-up stock issue of \$1,000,000 and a bond issue of \$4,000,000. Thus they materially strengthened their position on the lakes.

§ 23. The growth of one other great interest must be mentioned. Mr. James J. Hill was a late comer in the Mesabi field and his achievements are therefore all the more remarkable. His interest in ore is as a transportation man and not as a steel maker, though in the beginning of his operations he was supposed to be closely affiliated with the

American Steel and Wire Company. The first and most important of his purchases was the buying in 1898 of all the Wright and Davis holdings in St. Louis and Itasca counties, including the fee of the Mahoning mine, the Longyear and Bennett mines, and the Duluth, Mississippi River and Northern Railroad, which had a hundred miles of track running north from Hibbing, and held large logging contracts. The price, \$4,000,000, paid for this enormously valuable property seems absurdly small, but when the purchase was made money was very tight and the owners were glad to turn their property into cash. Next Mr. Hill paid \$1,000,000 for the Duluth and Winnipeg road, which gave him an ore dock at Superior. As the most of his acquisitions of ore land have been made since the Steel Corporation was formed, they will be dealt with in the final chapter.¹

§ 24. In giving attention almost exclusively to the Carnegie Company, the Consolidated, and the Minnesota Iron Company, there has been no intention to overlook the other great interests which took so prominent a part in the later development of the Lake Superior region. These three have been selected because they illustrate the main contention of this essay and because, in a way, their growth was the central fact of the history of the past decade. The manner in which other steel companies, such as the Federal, the National, the American Steel and Wire, and the Republic Iron and Steel, sought to rival the Carnegie Company is known to every student of recent industrial history. It is interesting to observe the persistence of the strong old-range companies, of which the Cleveland-Cliffs may be taken as a type. The manner in which, during the years of depression, they held their position by generous invest-

¹For a sketch of Mr. Hill's operations up to 1903 see "Hill Ore Holdings on the Mesabi," in the *Iron Trade Review*, February 19, 1903.

ment of capital in mines and transportation agencies and reaped the harvest of the good times following, is a matter of no small importance. The development of firms of ore agents, such as M. A. Hanna and Co., Picklands, Mather and Co., and Tod, Stambaugh and Co., into independent ore concerns and mine owners, would furnish material for a separate monograph. It should be understood therefore, that this essay omits the study of these other companies only from lack of space.

§ 25. The following brief summary gathers up the various threads of theory scattered through this chapter.

After a long period of falling prices and steadily declining costs, there came in 1893 a panic which tied up the country's financial resources and brought general business to a standstill, the iron trade, as is usual in such crises, being the severest sufferer. The price of ore, which at the beginning stood at the lowest figure then known, went down continuously, with only one short season of recovery, until the product of the mines brought little more than half the low price prevailing in 1892.

Coincident with this unprecedented depression occurred the development of the Mesabi range, which was able to produce ore at figures far below any the old ranges had yet reached. The hard times and monetary stringency quickly bankrupted most of the small concerns just starting on the Mesabi, and the whole range was immediately divided between two powerful interests, which with abundant financial resources bought and seized the properties of the distressed companies for almost nothing.

On the old ranges the weak concerns were being destroyed at the same time. Owing to low prices and the unprofitable nature of the industry these ranges fell a prey to the large companies in only a lesser degree than the Mesabi, the greater centralization on the latter being due

to the financial weakness of its operating concerns as compared with those of the older districts.

During this period the Carnegie Company entered upon the policy of mine ownership with the idea of supplying their own furnaces, and other steel companies did the same thing, thus making the financial resources of these vast concerns available for the exploitation of the Lake Superior deposits. The greatly increased capital used in mining was held by a few corporations, which speedily partitioned the whole region among themselves.

As larger and larger amounts of money were invested in canal improvement, bigger vessels, and better machinery for loading and unloading, the cost of transportation was speedily lowered, and with the steel companies reaching back to the mines, the mines reaching forward to the furnaces and steel mills, and the ore agents reaching in both directions, it was but natural that the control of transportation should fall into the hands of one or another of these parties. Therefore, by the end of the hard times the carrying of the ore, like the mining, was pretty well concentrated in the hands of the consuming companies.

The years of prosperity after 1898 instead of checking the tendency to centralization only confirmed it by bringing about a union of the steel companies and the consequent consolidation of their ore holdings.

The cost of production had been reduced so low by centralized management and by union of mines, transportation agencies and manufacturing plants; the required output had become so tremendous and the necessary equipment so expensive, that the small producer, by that very fact, was shut out of the field, and no chance was left for any concern which had not the strength of a full-grown giant. The development since 1901 has simply carried toward their conclusion the tendencies then in operation.

CHAPTER VI

THE PRESENT SITUATION—MONOPOLIZATION

§ 1. During the years when the Carnegie Company was getting hold of the best of the Lake Superior ore properties, the other steel companies were scarcely less active in assuring themselves supplies of raw material. If one company was to mine and transport its own ore, its competitors must do the same. The formation of the Federal Steel Company in 1898 by the amalgamation of the Illinois Steel Company, the Lorain Steel Company, the Elgin, Joliet and Eastern Railway, and the Minnesota Iron Company, put the resources of the last-named concern definitely at the disposal of the Carnegie Company's great western rival. The American Steel and Wire Company early entered the western Mesabi and pursued the policy of purchasing ore land, with a very fair degree of success. The National Steel, National Tube, American Tin Plate, American Steel Hoop, and other concerns, while none of them secured by any means so strong a position as the Carnegie or the Federal, yet all undertook with varying degrees of success to supply their own needs as to raw material and transportation.

The *Iron Age* said, in April, 1899, that not a quarter of the output of the Lake region for that year would be shipped by independent companies. The following week it observed that within three months all of the three important properties around Negaunee, on the Marquette range, had passed into the hands of new and much heavier concerns and that to all intents and purposes the independent miner was

pretty well eliminated from the Negaunee vicinity. In August of the same year it said editorially:

Soon, yes, to-day, the iron-mining business of the Lake Superior mining region is in the hands of six or seven concerns. The Oliver and Minnesota, ore supplies respectively for the Carnegie and Federal companies, are close together in the lead, with the former to-day in apparently better position owing to its readiness to take properties, while the latter was resting on its laurels. How they may stand in respect to each other to-morrow there is no telling.

Beside the large steel combinations there were the merchant furnaces of the Ohio valleys, whose needs were largely supplied by the Mahoning and Biwabik mines, in which they were largely interested.

In this state of affairs, with all the steel companies more or less self-contained, a fight to a finish might perhaps have been expected, but as Meade has pointed out,¹ the financial condition of the newly-formed consolidations unfitted them to carry on a war. When the Carnegie Company renewed its threat to build tube works at Conneaut, promoters and underwriters quickly got together to prevent the loss which they would have incurred by the fall in the value of their unsold securities inevitably consequent upon a declaration of hostilities. Thus the United States Steel Corporation was formed.

§ 2. If the position of the Oliver, the Minnesota, and the Consolidated companies had been a commanding one, what shall we say of the Steel Corporation, which united all their holdings and also gathered into its grasp all the properties of the other steel companies mentioned? Its first annual report showed that out of 104 mines making

¹ *Trust Finance.*

shipments in 1901 the Corporation owned 65, including such celebrated deposits as the Chapin, Aragon, Norrie, Aurora, Tilden, Pioneer, Mountain Iron, Fayal, Auburn, Adams and Monroe, with a part interest in the Pewabic, Chandler, Biwabik and Mahoning.

It owned the two principal Minnesota railroads, the Duluth and Iron Range and the Duluth, Missabe and Northern, the possession of which gave it a monopoly of transportation from the Vermilion range and also assured control of the major part of the Mesabi tonnage, as many of the small independent owners who still remained outside the combine were tied up by contracts with these roads. It owned the Elgin, Joliet and Eastern Railway, the Chicago, Lake Shore and Eastern and the Bessemer and Lake Erie, and was thus able to carry ore from lake to furnaces over its own lines.

On the lakes it had a fleet of 112 vessels which covered two-thirds of its requirements in the way of water carriage.

It is not strange that the general public thought for the moment that a monopoly had been attained in the steel business. Such, however, was by no means the case. The trust during its first year produced approximately 60 per cent of the entire output of iron and steel, its exact figure for iron ore standing at 61.6 per cent of the Lake Superior shipments.

It was in the ore field that the most dangerous possibilities of monopoly lay, and it was generally expected that the trust would push rapidly forward in the direction of exclusive ownership. For the time being no move was made, however, doubtless because financial support was wanting, and the brief interval of waiting thus given was enough to allow a strong rival to plant himself firmly in that portion of the field which the trust had not pre-empted, the western Mesabi.

§ 3. Passing by for the moment the story of the Hill acquisitions, we note that the Steel Corporation has by no means stood still since 1901, relying on the strength of the position it had already gained at that time. By purchasing the Union Steel Company in December, 1902, it acquired the Sharon and Penobscot mines in fee and the Donora and Sweeny leases, containing approximately 40,000,000 tons of ore; in May, 1904 it bought the Clairton Steel Company, thus getting the 20,000 acres of land on the Marquette range on which the Champion mine is located, one-half of the fee of the Clairton mine and a lease of the Little and Prindle mine, both on the Mesabi. In addition to these purchases the report of the corporation for 1902 shows expenditures of \$985,322 for "additional fee properties, leases, *etc.*, acquired" and further payments of approximately \$1,000,000 on account of the purchase of additional real estate, timber lands to provide mining timber, construction and additions to mining plant and equipment. In the reports for 1903 and 1904 the amounts expended for acquisition of additional ore lands are lumped with the other expenses of the iron mining companies, the total amount so expended being \$1,040,525.68 in 1903 and \$1,580,655.60 in 1904. The report for 1904 says:

In addition to the capital outlays required for the foregoing [additions to equipment], the above total expenditures include payments made during the year for acquirement in fee, or by leases on a royalty basis, of additional property which contains large tonnages of iron-ore. As much of the ore acquired has been obtained on a royalty basis, which does not represent a large initial cash outlay, the capital account increase is small in comparison with the amount of ore secured. A considerable amount was also expended for the acquisition of timber lands to provide timber for mining operations.

While it is impossible for any one not in the inner circle of the Steel Corporation to tell just what has been done during the past three years, the mere facts here drawn from the official reports and the well-known activity of the great company in exploration and leasing during that time show that it is fully alive to the advantage which it already has in the possession of unequaled ore properties, and that it is determined to maintain and even increase that advantage if possible.

§ 4. If we return now to the story of Mr. Hill's activities on the Mesabi, we take up one of the most interesting chapters in the whole history of the Lake Superior region. The way in which the Great Northern interests entered the Mesabi field in 1898 and at the first move secured a respectable portion of the tonnage, has already been mentioned. No sooner had Mr. Hill secured a connection from the western end of the district to the lake and a dock at West Superior, than he began building a spur from his road at Hibbing due east along one of the best parts of the range, thus raising high the hopes of those who wanted to see some really effective competition with the Consolidated and Minnesota companies, which monopolized the transportation lines to the lake. Some ore lands were gradually secured by Mr. Hill's Eastern Minnesota road, as it was called, but there was no marked development up to 1901.

With the formation of the Steel Corporation, all was changed. The trust owned both of the other Mesabi roads, and it was evident that its policy would be to haul all of its own ore and as much more as it could. Moreover it was supposed that the Corporation would continue the acquisition of undeveloped ore lands. As previously stated, however, it did not do this immediately. Mr. Hill saw his opportunity, and was quick to seize it.

In order to make his road profitable it was evident that he must have sufficient ore of his own to maintain a heavy traffic. With abundant funds obtainable at the lowest rate he began buying leases and fee tracts by the wholesale, but very quietly. The stocks of many companies owning lands on the ore-bearing formation were secured at low prices, state leases were bought at advances over the royalties demanded and many tracts were purchased outright, though they were not certainly known to contain much ore. By advancing cash to needy companies for the purchase of other lands he obtained control of the traffic of many ore bodies, a favorite method being to assist intending buyers of mines to a part of the cash needed in return for contracts for traffic at the going rate. In this way he tied up a large amount of ore outside of his ownership. Another method was to permit exploration of his own lands on a royalty basis, in return for traffic which the intending explorers might furnish from mines which they already held.

By one means and another the Eastern Minnesota road thus came to have extensive ore properties, including large fee tracts and state and private leases of more or less value. Among them are the Mahoning, Stevenson, Leetonia, Burrows and several other important ore bodies and large areas of unexplored land which may be very valuable. What all this property is actually worth no one knows, unless it be Mr. Hill himself, but in any case its gathering together has been a feat of business genius, and has placed the possessor in a position where he is to-day the most formidable rival of the Steel Corporation in the mining field.

That Mr. Hill's work was successful in its main object is shown by the fact that the Eastern Minnesota last year carried almost exactly one-third of the whole Mesabi output. It is a marvelous testimony to the power of large capital skilfully managed to accomplish results under difficulties,

that this road, which seven years ago did not exist, should to-day hold the remarkable position it occupies.

§ 5. We have now sketched in outline the present position of the two largest holders of Lake Superior iron mines. It remains to give some idea of what other large concerns are doing. The following table of shipments, drawn from the *Mineral Industry* for 1903 and Mr. Woodbridge's review of the Lake Superior mining industry in the *Engineering and Mining Journal* for January 5, 1905, shows the shipments of some of the largest producers for the last three years:

	1902	1903	1904
United States Steel Corp. . . .	16,063,179	15,363,355	11,174,000
Corrigan, McKinney and Co. . . .	2,190,000	1,565,000	2,454,000
Cleveland-Cliffs Iron Co.	1,720,000	1,315,000	1,226,125
Pickands, Mather and Co.	1,270,000	1,100,000	1,144,700
Joseph Sellwood	383,000	831,000	766,804
Jones and Laughlins	442,000	631,000	467,260
Ferd. Schlesinger	309,000	320,000	257,744
Republic Iron and Steel Co. . . .	336,000	493,000	310,190
Penn Iron Mining Co.	792,000	1,000,000	141,947
Mahoning Ore and Steel Co. . . .			707,500
Biwabik Mining Co.			647,600
Pewabic Mining Co.			361,814
International Harvester Co. . . .			244,403
Total Lake Superior	27,571,121	24,289,878	21,726,590

In 1902 the four largest concerns made 77 per cent of the entire shipments; in 1903, 79.6 per cent; in 1904, 73.7 per cent.

No mere table of shipments can give, of course, any idea of the interrelations of the various concerns and their connections with the steel companies. Thus several of the large steel companies whose names do not appear at all on the table are extensively interested in Lake Superior mines and have, in one way and another, secured substantial ore reserves. If a steel company has a twenty or fifty-year

contract with a mining corporation to take its entire output on a fixed basis, the situation differs little from that in which the company works through its own mining organization, except that the advantage of improvements accrues to the mining concern and not to the steel company, and that the latter is free from some of the risks it would undergo if it carried on its own mining operations. A number of the large producers listed above have the closest affiliations with various steel and iron producing interests, the Mahoning and Biwabik mines, for example, as previously stated, being the source of ore supply for the valley furnaces. To undertake to trace in detail all the relations between mining concerns and steel companies would be a task as difficult as it would be useless for our purpose. Suffice it to say that a steel company without a certain ore supply is to-day in an exceedingly hazardous position, and that a mine which lacks close affiliation with a steel company is in a situation little less precarious than is such a steel company. In fact, it is becoming progressively more difficult to carry on any branch of the iron and steel industry without having practical ownership of raw materials and the equipment required to transform the ore into the ultimate product.

§ 6. The enormous enlargement in the scale of operations which has occurred since the early days and the growth of the companies are clearly indicated by the following table, which shows the number of employers, the product in tons, and the product per employer for each range and for the entire district at five different periods:

LAKE SUPERIOR IRON ORE PRODUCTION, 1873 TO 1904

District.	1873		1882		1893		1897		1904						
	No. employers	Total product	Product per employer	No. employers	Total product	Product per employer	No. employers	Total product	Product per employer	No. employers	Total product	Product per employer			
Marquette .	37	1,162,458	31,418	41	1,829,394	44,619	22	1,835,913	83,449	18	2,715,035	150,835	11	2,504,951	236,814
Menominee .				25	1,136,018	45,440	22	1,466,197	66,645	14	1,937,013	138,358	12	3,047,096	253,925
Gogebic . .							18	1,329,385	73,854	15	2,258,236	150,549	18	2,288,400	127,133
Vermilion .							2	820,631	410,310	3	1,278,481	426,160	1	1,299,265	1,299,265
Mesabi . . .							11	613,620	55,783	13	4,280,873	329,298	21	12,086,878	575,566
All ranges .	37	1,162,458	31,418	66	2,965,412	44,930	72	6,065,716	84,246	60	12,469,637	207,827	46	21,726,590*	472,317

* Including all rail shipments, estimated at 500,000 tons.

The figures for 1882, 1893 and 1897 are drawn from a table given by Mr. William G. Mather, in *Proc. Lake Sup. Mining Inst.*, vol. v, p. 11; those for 1873 from *Rep. of the Mich. Commissioner of Mineral Statistics for 1877-8*; for the data for 1904 I am indebted to the courtesy of Mr. A. I. Findley, editor of the *Iron Trade Review*.

The facts exhibited in this table lend point to the following suggestive remarks of Mr. William G. Mather:

The Lake Superior mining industry is now in the era of the large corporation or employer, whose organization is as costly as it is efficient; whose fixed expenses are large, and whose aim must therefore be to work regularly, to produce this year as much as, if not more than, last year, so that these fixed charges per ton may not increase, but decrease. The employer cannot now easily reduce his cost when prices and demand are depressed; a complex organization (necessary with a large business) cannot conveniently nor economically be suddenly adapted to a decreased output; men cannot be discharged now and new ones employed later without impairment of system, discipline and efficiency.

We have, then, arrived at this stage of affairs: First, low prices and expensive managing organizations, with high fixed charges needing regular and large output; second, a knowledge that the extent of our deposits and future market prospects are of a kind to justify large expenditures for the most efficient plant and best organization.¹

§ 7. It may be well to emphasize once more certain of the concrete advantages derived by a few powerful corporations in the iron mining industry from the concentration in their hands of the large capital employed. These advantages are such as to make mining to-day absolutely impossible save for a concern thus equipped.

The first of these gains is the use of adequate and expensive machinery in every mine worked. It is worse than useless to undertake to produce ore in these days without the latest and best mining machinery, and there must be continued progress in putting in new equipment in the mine, precisely as in the factory. Machinery has wonderfully

¹ *Proc. Lake Superior Mining Institute*, vol. v, pp. 11-12.

cheaped the cost of production, and at the same time has led to the lowering of prices until production with insufficient plant is wholly impossible except at a continuous loss.

Second, the result of such equipment is a large output from each mine. Last year there were 15 mines in the Lake Superior region which produced more than 500,000 tons each, and the Fayal in 1902 showed an output of almost 2,000,000 tons. With such an output fixed charges are reduced to the minimum and the cost of production is carried down far below anything which the smaller mine can reach. The influence of the steam shovel and cheap Mesabi ores in compelling the old range mines to increase their output is apparent from the most cursory examination of their shipments.

§ 8. In this connection it is interesting to observe the increasing use of the open-pit method at the present time. In the early days many Mesabi mines were opened underground, partly because the companies operating them could not stand the expense of the heavy initial outlay necessary for steam shovel work, partly because the advantages of steam-shovel operation were not thoroughly understood. At present, with the wealthy steel companies furnishing all the needed capital and with the experience of a dozen years showing the economy of open-pit work, there is a marked tendency to extend the use of open-pit methods. This tendency has shown itself even on the old ranges in those few instances where open works are practicable.

On the Mesabi there is, moreover, a decided increase in the depth of the stripping which the mining captains are willing to undertake. At first it was thought economical to strip a foot of overburden for a foot of ore, if the total thickness of the overburden was not more than 35 or 40

feet. In 1897 Bailey stated ¹ that one foot of overburden to two feet of ore was about the limit, but this tendency to less stripping is now materially changed because timbering costs from ten to twelve cents a ton for underground mining on the Mesabi. The high level of wages and the greater probability of strikes where many men are employed together underground also favor the open-pit method, while heavier machinery makes deeper stripping practicable. "It is quite possible that, as time passes, it will be found that scarcely a large mine of the Mesabi has been opened underground that might not have been more economically handled by some open-pit method—providing always that the deposit is uniform and clean and not mixed with rock, sand and other material." ²

Last year 50 per cent of the Mesabi product was mined by steam-shovel and about 7 per cent by milling. The striking advantages of the latter system under certain conditions are causing an extension of its use. A product as high as forty tons a man per day has frequently been made in milling mines, but such a record cannot be maintained with proper deadwork. In general, the gaining of ores by milling will run at least twenty-five to thirty cents per ton cheaper than the caving, square set and slicing systems of underground work, while the steam shovel, in mines of reasonable output, will take out ore at a cost from ten to fifteen cents below that of the milling system. The two methods of open-pit work steadily gain on the underground system, and they are methods which can be applied only by the strong company. ³

§ 9. A third point of superiority of the large company

¹ *Trans. Amer. Inst. Mining Engineers*, vol. xxvii, pp. 529-536.

² Woodbridge, *Engineering and Mining Journal*, Feb. 9, 1905.

³ *Ibid.*

is its ability to mine all kinds of ore. No matter how valuable a mine may be, or of how high a grade its ore, it cannot furnish the material for all kinds of iron and satisfy the demands of all consumers. The larger the organization and the greater the number of its mines and the variety of their ores, the more completely can it meet the wants of its own furnaces and those of its customers. The importance of these considerations is evident when one observes, for example, the great demand which has sprung up for the high-silica, low-phosphorus Menominee ores since the opening of the Mesabi mines, whose product needs these other ores for mixture. Illustrations of the same kind might be multiplied. The great gain arising to a company owning mines which furnish all possible varieties of ore is clear.

§ 10. This suggests yet a fourth advantage of the great concern. The capital of a mining company in its mines is being constantly used up. The company must therefore continually open new deposits. The larger the scale of operations the smaller is the dependence of the producer on any individual mine. Moreover as the largest companies are in general financially strongest, the drain imposed upon their resources by such compulsory purchase is relatively less than in the case of smaller concerns. They are able without inconvenience to furnish the money required for the acquisition of the best new properties, a thing which their smaller rivals cannot do. As the possibility of monopoly draws nearer, this power of the large companies assumes a rapidly increasing importance.

§ 11. Of no less utility to the great concerns is their ability to apply scientific methods of exploration and development. In the whole history of Lake Superior mining there has been no more remarkable change than the abandonment of the old haphazard methods for the modern scientific sys-

tem. The present practice of the large companies is to keep a body of trained men constantly at work making systematic explorations. When a deposit is found it is carefully examined by test pitting and diamond drilling if necessary, the system of mining to be adopted is worked out in the office by the engineers before a pick is put into the ground, and the plan of operations is laid with a view to taking out the whole ore body in the most economical way.

It is impossible for one not familiar with actual mining operations, as at present conducted, to realize the care and outlay which the great companies are putting into preliminary work of this sort. Their geological maps put those of the state and national governments, admirable as they are, to shame. Promising ore properties are honeycombed with drill holes and by plotting these holes on paper a record is obtained of the size and shape of the deposits and the character of their ores, so that the management incurs a minimum of risk at each stage of operations.

To carry out such a system as this, which was first inaugurated by the Lake Superior Consolidated Company, requires a trained force of engineers with ample facilities, and demands the utmost harmony between them and the operating force at the mine. The economy of work attainable by such a system is possible only for the strong company which can incur the heavy initial expense the method entails and which can spread its cost over a large annual product.¹

§ 12. A fifth important result of the large capital at the disposal of the great companies and the scientific methods which they are consequently able to employ is the new view which they take of the ore deposits. Instead of regarding them as inexhaustible stores of wealth on which

¹ Woodbridge, "The Mesabi Iron Ore Range," in the *Engineering and Mining Jour.*, Feb. 9, 1905.

they may draw at pleasure, and therefore working them as the immediate financial needs of the company or the temporary exigencies of the market may dictate, they examine each ore body with the greatest care, ascertain the quantity and quality of ore which it contains, decide just how its product may most advantageously be used in connection with other ores at their disposal, and determine upon that policy of operation which will make the mine best serve the permanent interests of the manufacturing company to which it belongs. In other words the steel companies have come to regard the mines as no less essential parts of their equipment than their mills and furnaces, and they have come to recognize that a permanently successful manufacturing business can be built up only on the foundation of an adequate ore supply. In providing themselves with such a supply they are obliged to take account of the fact that a modern manufacturing business under stress of competition must grow without ceasing and that they must therefore assure themselves a supply of raw material which not only is adequate to their present needs but will be equal to increased drafts upon it in the future. We shall hear no more of "inexhaustible" mines. Science has made guesswork unprofitable in business, whether it deals with the present or the future.

§ 13. Turning now from mining to transportation we note that here capital has been cheapening cost no less remarkably than in the mines and that here also the large company enjoys marked superiority. It is unnecessary to detail technical improvements. The most important advance of recent years has been the evolution of automatic machinery for the rapid handling of ore at the docks. A cargo of 10,000 tons has been unloaded in four and one-half hours and loaded in a third of that time. The limit of speed and economy, however, has by no means yet been

reached. The lake vessel continues to grow rapidly, the average carrying capacity of vessels now building being almost twice as great as that of the steamers under construction only two years ago. The freighters to come out of the lake yards this year can move 4,500,000 tons of ore in a season.¹

The advantage of the large company in transportation matters is twofold. In the first place, through the volume of its business it is able to command the best rates from existing railroad and steamship lines. By the threat of building its own steamers, or even, if its business be very large, its own railroad, it can compel reductions of rates which it considers excessive.

This possibility, however, under existing conditions, is of less importance than the actual ownership of the agencies of transportation. The tying together of mines and steamships by the bond of common ownership, has proceeded so far of late as to lead the *Iron Age* last year to remark that a vessel owner without a guaranteed tonnage from the mines would soon be in as helpless a state as a Mesabi railroad in the same condition. The gain to the steel company in owning its own vessels as well as mines, and thus being free from the wild fluctuations of lake rates and ore prices is too evident to need more than a mere statement. The manner in which the Carnegie Company developed Conneaut from a comparatively insignificant position to become in a dozen years the third greatest receiving port on the lake, illustrates how rapidly the steel companies built

¹For present methods of transportation see Piez, "Handling and Storing of Iron Ore," in *Proc. Engineers' Club of Philadelphia*, vol. xix, pp. 177 *et seq.*; Mason, "Movement of Iron Ore," *ibid.*, vol. xx, pp. 117 *et seq.*; Woodbridge, "The Mesabi Iron Ore Range," in *Engineering and Mining Journal*, March 23, 1905.

up their transportation organizations, once they had committed themselves to the carrying business.

§ 14. The advantages above enumerated of the large company are not dependent, in general, simply on the size of the organization, even though mere bigness is important in securing the economies mentioned. The possession of adequate capital is the essential thing, and it is because the largest companies are usually the best supplied with capital that they are industrially most efficient.

The Lake Superior iron-mining industry has been singularly free from those unfair methods of competition which are so often alleged as the leading causes of the growth of monopoly. Though there have been some complaints of the fixing of high rates by the mining concerns which owned the railroads, combination in iron mining has, generally speaking, not been brought about by railroad discriminations, local price-cutting or factors' agreements, which have exerted so wide an influence in other industries. It has depended chiefly on the superior economy of aggregated capital and on the rapid increase of the capital of individual companies as compared with that necessary to work the mines. The small producer has been eliminated because he was not economically equal to the task imposed upon him, while the large company has grown yet larger because it was more and more able to cope with the problem presented by falling prices and rising costs.

For the same reason the field has been practically cleared of the independent concerns, and their places have been taken by the steel companies and their mining allies. In his annual review of the industry in the *Iron Age* for January 5, 1905, Mr. Woodbridge says:

The number of merchant ore firms is even less than appears. Some are already far oversold, according to best information,

on their better ores; others, who may be selling, should conserve every pound they control for associated steel-makers; others are such small factors that they cannot be taken seriously. The United States Steel Corporation is not the only ore miner that refuses to sell; some, indeed, are buying. The proportion of free ore—that is, of ore for sale to furnace interests not connected with mines—is far less than is generally supposed.

§ 15. Bearing these facts in mind let us glance in conclusion at the position of the greatest of all the steel companies and see if we can form any estimate as to the probabilities of the immediate future. It should be remembered that the issue involved is not merely the control of the mines, but of the iron and steel industry as well; for as Mr. James J. Hill has well remarked:

The growth of our enormous iron and steel industries, which are pointed out as the result of our protective tariff, can be more surely traced to our magnificent reserves in the iron mines of Michigan and Minnesota than to any other source. To-day, if these mines were closed, our superiority in the iron and steel trades of the world would be gone forever.

Despite the increase of southern competition and the encroachments of the basic Bessemer and open-hearth processes on the older Bessemer method, it still remains true that the immediate future of the American iron trade rests in the hands of those who hold possession of the pure ores of Lake Superior. Centralization in mining means in no small degree centralization in manufacture. Hence the importance of a correct estimate of the influences now at work in the mining industry.

The apprehensions of those who feared immediate monopoly with the formation of the Steel Corporation may be dismissed as groundless. Whatever the proportion which

its ore reserves bear to the total supply still buried in the Lake Superior region (a proportion which no one knows with any approach to accuracy), it must be remembered that metallurgical progress and the exhaustion of the richer deposits are constantly making marketable leaner and more phosphoric ores and widening by so much the supply to be monopolized.

Whatever may be the facts with respect to reserves, then, we know that the trust in 1901 made 61.6 per cent of all the Lake Superior shipments; in 1902, 60.4 per cent; in 1903, 58.6 per cent; in 1904, 51.1 per cent. This slight decline in its percentage during the first three years of its existence and the remarkable falling off of last year are capable of two interpretations.

§ 16. First, we may argue that just as in the case of so many would-be monopolies, new competition has arisen which the Corporation was unable to control. There is a degree of truth in this view of the matter. The high prices of the four years immediately preceding 1904 stimulated exploration and development to the last degree, and the independents did not hesitate to bid up properties which the trust would doubtless have been glad to secure. If the financial demands imposed upon the Corporation by its over-capitalization had not been so great, it would probably have been even more aggressive than it has been in getting hold of new properties. There can be no doubt that it will push forward on the path of monopolization as far and as fast as proves economically practicable, for such is the dictate of sound business policy. To control the Lake Superior mines is to dominate the immediate future of the American iron industry. The decline in the trust's proportion of shipments might accordingly be taken to indicate that it is losing its grip on the mining situation.

§ 17. Such an interpretation of the facts lacks much of

being a full explanation. The falling off in trust shipments may much more reasonably be attributed to far-sighted action on the part of the managers of the Corporation's affairs. With ore selling at from \$4 to \$6 during 1901-2-3, they wisely pushed their mines and got out a large product for which they found ready sale at a good profit, either in the form of ore or of finished goods. In 1904, with ore \$1 to \$1.50 lower than during the preceding year, and half the season's shipments bringing no profit, they wisely cut production and shipments to their lowest limits, preferring to let their competitors exhaust their reserves, if they wished, by selling at a loss, while they themselves held back against the day of better things.

By contrast, the action of certain other large interests appears amazingly short-sighted. The rich new Stevenson mine is reported to be already oversold, and its ore has in any event been thrown on the market with reckless disregard of the effect on prices. Prudence would dictate that where a vast deposit can be cheaply worked and so sold with a large profit when prices are only fair, the product should be held back in bad seasons, in the assurance that it can be sold in good years for an additional profit more than enough to make up for the delay. Of course it requires a strong company, which can afford to wait for profits, to carry out such a policy.

In managing mines, a company has always to remember the nature of its ore reserve as a capital asset. Once gone, it is gone forever. Therefore the aim of the company should be to secure from it the largest possible return, holding in view the entire life of the deposit. This consideration becomes all the more important as the limits of available supply come more clearly into view, and the possibility of ultimate monopoly begins to be seriously discussed. The argument holds good for the steel company no less than for

the independent mining concern. It is an outcome of that long-time view of business affairs which is coming to supersede the reckless hand-to-mouth policy of earlier days.

In this view, the wisdom of the Steel Corporation is evident in declining to make a spectacular showing by attempts to increase its proportion of the total output when there is a greater profit in allowing the proportion to decline temporarily, with a more than compensatory increase in probable profits later.

It is possible, of course, to neglect the present and to give too exclusive attention to the future. If the Steel Corporation is looking to an advantage to be derived twenty years hence from a monopolistic control of Bessemer ores, it may well find itself cheated by other processes displacing the Bessemer. But it is unnecessary to put any such distant interpretation on the policy of the corporation. Its unwillingness to exhaust a valuable asset like its ore reserve, except at prices which show a fair profit, is to be commended, and will do something to help in bringing about that steadiness of prices which it desires.

§ 18. The price policy of the Steel Corporation is of course complicated by the fact that the cost of its ore is little affected by changes in ore prices, while some of its competitors find their cost of manufacture seriously raised by higher prices for raw material. Hence the Corporation works for high ore prices, and the merchant ore companies, curiously enough, with a view to protecting their customers strive to keep values down. The situation is an abnormal one and can only result, apparently, in clearing the field entirely of independent ore firms. Even when that is accomplished the ownership of the Mesabi railroads and such other ore carriers as may be acquired would make it advantageous for the Corporation to keep up the cost and price of ore by maintaining high railroad rates. The effect on

companies which have not an independent ore supply or railroad connection can be imagined. The economical possibility of complete equipment through having ore reserves sufficient to warrant the building of independent railroads, if necessary to keep down rates, has been pointed out in an earlier chapter.

§ 19. The real importance of the final disposition of the Hill ore holdings now becomes apparent. Many mistaken ideas are current concerning the possibility of their sale to the Steel Corporation, and it is supposed that such a transfer of ownership would give the trust almost a complete monopoly of the Mesabi ore-bearing lands. As a matter of fact a great many of the Hill mines are already under lease to independent steel companies on such terms that there could be no possible gain to the trust, from the point of view of ore supply for its furnaces, in buying up the fee or the underlying leases. What such a transaction might accomplish is the transfer of the Eastern Minnesota railroad to the Corporation, for Mr. Hill would doubtless insist on its being the whole bargain or none; and the Steel Corporation would unquestionably be equally anxious to get the road, whose acquisition would give it a monopoly of rail transportation from the Mesabi, while its control of undeveloped ore lands and the existing tonnage contracts of the developed mines with the railroads make it improbable that it would ever be profitable to build a competing line. Give to one concern a monopoly of the transportation of the product of that range which dominates the whole Lake Superior iron-mining business, and the gain that would accrue to it is patent. It would be even greater than the advantage possessed by the Minnesota and Consolidated companies through their ownership of the railroads in the early days, because now there would be little fear of the building of new roads to keep down rates. Existing contracts, of

course, must be taken into account, yet the benefit to the trust of buying up the Hill properties, even though it should not make great gains thereby in regard to supplies of ore, is large enough to warrant it in paying a generous price.

Why does not the Corporation buy out Mr. Hill, if that action would give it such a commanding position? The answer is simple. Mr. Hill's price is too high and the Corporation cannot afford to furnish the money required. The sum which it can put into mines and mining is strictly limited by practical business requirements, and while it might possibly in case of necessity command the funds to buy these properties, its present industrial and financial position does not yet warrant such action. To put the matter once more in terms of our theory, the capital at its disposal has not yet grown up to the measure of the demand made by the whole region. Sooner or later it may be forced to purchase the Hill interests in self-defense.

Assume that a combination of such companies as the Lackawanna, Jones and Laughlins, the Republic Iron and Steel, and a dozen others that could be mentioned, should take over the Hill properties. The Steel Corporation, loaded down with a heavy burden of securities, would be forced into competition with a group of concerns over which it had but slight advantages. Whatever monopoly it has in the ownership of the Connellsville coal field it is bound to lose with the growth of the by-product coke process. So far as equipment goes, the other companies are no whit behind the Corporation. As to location, many of their plants are even better situated than most of the trust mills. As for transportation, they have their own steamships and the supposed purchase would give them their own railroad. The only thing the trust could do to save itself from a destructive competition would be to forestal its rivals in getting possession of the Hill lands and railroad. That it would be glad to

do so is unquestionable; that it would be happy to monopolize the lake region is equally certain; if it is ever able to accomplish this result it will be because its capital has grown up to the point where it can adequately finance the whole Lake Superior mining industry.

§ 20. It is extremely dangerous to hazard any guess as to the future, but it seems safe to say that the importance of the Lake Superior ore supply will increase rather than diminish in the immediate future. The westward movement of population and industry is steadily bringing the furnaces nearer to the mines, and the shores of Lake Erie furnish the best location in the north for steel-making to-day. Without question the best policy for any concern which intends to make steel during the next twenty-five years is to intrench itself firmly in the Lake Superior region. It is equally good policy for any company which may be able to do so to monopolize that region, even at a rather high cost.

The Steel Corporation could bring the independent ore companies to their knees fast enough if only rival steel companies would give it a free hand, but the independent steel makers, as well as the trust, have planted their feet on the ground and seem quite as ready as their great rival for a fight to a finish.

We should not be deceived by appearances, however. It is quite inconceivable that a destructive warfare between a small number of powerful steel companies should long continue. The moment the number of competitors is reduced so as to become manageable, combination is possible, and with that possibility in the background, fierce competition is not likely long to continue. The formation of the Steel Corporation itself is a case in point. Further combination among northern steel makers does not seem to be immediately in prospect, yet there is no serious reason for believing that it will not occur. Such combination would

carry yet further the concentration of control in the mining industry, and there is no inherent reason why a monopoly of the Lake Superior iron mines should not be achieved to all intents and purposes as absolute as is the monopoly of the anthracite coal fields to-day. Then the only restraint on the northern iron makers would be the competition of southern and eastern manufacturers who could derive their ores from other sources than Lake Superior.

To predict such a consummation would be to exceed the bounds of scientific caution, but it does not require a prophet to discern the direction in which things are moving. As the great companies, and particularly the greatest of all, grow stronger, they will be able to offer greater and greater inducements to the small ore-holders, the profits of independent operation will become more and more precarious, and thus the process of concentration will steadily proceed. Meantime combination among the steel companies is likely to continue in one form or another, and thus the tangled skein of mine ownership will be snarled yet tighter. The single corporation or group of corporations may come at last to have all the capital needed to obtain all the mines and work them economically.

§ 21. To discuss the possibilities of such a situation would be idle at present. It would certainly extend into the domain of what has been held to be purely private industry certain ideas which have already begun to be entertained by the student and the statesman when considering public franchise enterprises. It might do something to shake our confidence in competition as a sufficient regulator of industrial relations in the industries which depend upon mines as the source of their raw material.

If the Lake Superior mines can be monopolized, why not those of the south and west as well? Given a northern combination, a southern one, and a western one, why should

they make war upon one another? Why should they not take the final step of consolidation? Monopoly as yet seems far away, but its outlines loom large before us. If ever it comes, it will be based, not upon any precarious foundation of unfair traffic agreements or illegitimate devices of traders, but primarily upon the sole ownership of the marvelous Lake Superior ore deposits, upon the possession of the great equipment required to work the mines cheaply, of the railroads and steamships needed to bring ore and fuel together at the furnace, and of the enormous plant necessary to convert the ore at lowest cost into the machinery upon which depends so largely our further progress in wealth and material comfort.

APPENDIX

The following tables give the average yearly price of No. 1 foundry pig iron at Philadelphia, the total production of all kinds of pig iron in the United States, the season contract price of Marquette specular No. 1 Bessemer ore delivered at Cleveland, the total shipments of Lake Superior iron ore, and the shipments by ranges, from 1854 to 1904; the season contract price of soft hematite non-Bessemer ore at Cleveland from 1883 to 1904; and the corresponding figures for Mesabi No. 1 Bessemer ore from 1894.

The figures of production and price of pig iron and shipments of ore are taken from the reports of the American Iron and Steel Association. The prices of ore shown are as follows: From 1856 to 1874 the price of standard Bessemer ore, as given by the Michigan Commissioner of Mineral Statistics in his report for 1890, p. 56; from 1875 to 1882 the price of Republic ore as given by the *Iron Age* during those years; from 1883 to 1896 the price of No. 1 Republic and Champion ore, as given by the Reports of the American Iron and Steel Association; from 1897 to 1904 the price of Marquette specular No. 1 Bessemer ore, from 1883 to 1904 the price of No. 1 soft hematite non-Bessemer ore, and from 1894 to 1904 the price of Mesabi No. 1 Bessemer ore, all as given by the reports of the American Iron and Steel Association.

The ore prices given before and after 1875 are not strictly

comparable, the prices of Republic ore from 1875 to 1890 being higher than those of standard Bessemer ore for the same years, as given by the Commissioner, by from \$1.25 to \$.25, or an average of \$.60 for the period. From 1875 on they are strictly comparable. Prices here given for the years before 1883 should be received with caution.

TABLE I

Production and Prices of Pig Iron and Lake Superior Ore, 1854-1864

Year	Price of Pig Iron	Production of Pig Iron	Price of No. 1 Ore	Shipments of Lake Superior Ore
1854	\$36.88	657,337		3,000
1855	27.75	700,159		1,449
1856	27.12	788,515	\$8.00	36,343
1857	26.38	712,640	8.00	25,646
1858	22.25	629,548	6.50	15,876
1859	23.38	750,560	6.00	68,832
1860	22.75	821,223	5.25	114,401
1861	20.25	653,164	5.25	49,909
1862	23.88	703,270	5.25	124,169
1863	35.25	846,075	7.50	203,055
1864	59.25	1,014,282	8.50	243,127

TABLE II.

Production and Prices of Pig Iron and Lake Superior Ore, 1865-1904.

Year	Price of Pig Iron	Production of Pig Iron	Price of No. 1 Bessemer Ore	Shipments of Lake Superior Ore	Price of No. 1 Soft Hematite Non-Bessemer	Price of Mesabi No. 1 Bessemer
1865	\$46.12	831,770	\$7.50	236,208		
1866	46.88	1,205,663	9.50	278,796		
1867	44.12	1,305,023	10.50	473,567		
1868	39.25	1,431,250	8.25	491,449		
1869	40.63	1,711,287	8.25	617,444		
1870	33.25	1,665,279	8.50	830,940		
1871	35.12	1,706,793	8.00	779,607		
1872	48.88	2,548,713	9.00	900,901		
1873	42.75	2,560,963	12.00	1,162,458		
1874	30.25	2,401,262	9.00	919,557		
1875	25.50	2,023,733	7.75	891,257		
1876	22.25	1,868,961	7.50	992,764		
1877	18.88	2,066,594	7.00	1,015,087		
1878	17.63	2,301,215	6.50	1,111,110		
1879	21.50	2,741,853	7.00	1,375,691		
1880	28.50	3,835,191	10.00	1,908,745		
1881	25.12	4,144,254	10.00	2,306,505		
1882	25.75	4,623,323	10.00	2,965,412		
1883	22.38	4,595,510	7.50	2,353,288	\$4.75	
1884	19.88	4,097,868	6.00	2,518,692	4.50	
1885	18.00	4,044,526	5.75	2,466,372	4.00	
1886	18.71	5,683,329	6.25	3,568,022	4.50	
1887	20.92	6,417,148	7.00	4,762,107	5.00	
1888	18.88	6,489,738	5.75	5,063,877	4.00	
1889	17.75	7,603,642	5.50	7,292,643	3.75	
1890	18.40	9,202,703	6.50	9,003,725	4.50	
1891	17.52	8,279,870	5.50	7,071,053	3.75	
1892	15.75	9,157,000	5.50	9,072,241	3.75	
1893	14.52	7,124,502	4.50	6,065,716	3.25	
1894	12.66	6,657,388	3.35	7,748,312	2.00	\$2.50
1895	13.10	9,446,308	3.30	10,429,037	2.25	2.50
1896	12.95	8,623,127	4.50	9,934,828	2.60	3.25-3.75
1897	12.10	9,652,680	2.80-3.10	12,464,574	2.25	2.10-2.30
1898	11.66	11,773,934	3.10-3.35	14,024,673	2.20	2.15-2.25
1899	19.36	13,620,703	3.21-3.50	18,251,804	2.00-2.15	2.25-2.40
1900	19.98	13,789,242	5.93-6.48	19,059,393	4.15-4.25	4.40-4.90
1901	15.87	15,878,354	4.66-4.92	20,593,537	2.85-3.15	2.75-3.00
1902	22.19	17,821,307	4.65-5.00	27,571,121	3.00-3.25	3.00-3.25
1903	19.92	18,009,252	4.85-5.15	24,289,878	3.60	4.00
1904	15.46	16,497,033	3.60-3.85	21,843,743	2.60-2.80	2.75-3.00

TABLE III
Shipments by Ranges

Year	Marquette	Menominee	Gogebic	Vermillion	Menabi
1865	236,208				
1866	278,796				
1867	473,567				
1868	491,449				
1869	617,444				
1870	830,940				
1871	779,607				
1872	900,901				
1873	1,162,458				
1874	919,557				
1875	891,257				
1876	992,764				
1877	1,004,682	10,405			
1878	1,016,865	94,245			
1879	1,106,602	269,089			
1880	1,316,552	592,193			
1881	1,567,370	739,135			
1882	1,914,745	1,032,647			
1883	1,305,425	1,047,863			
1884	1,558,033	895,634	1,022	62,124	
1885	1,430,422	690,435	119,590	225,484	
1886	1,627,383	880,006	756,237	304,396	
1887	1,860,043	1,199,343	1,285,265	394,252	
1888	1,921,525	1,165,039	1,424,762	511,953	
1889	2,634,817	1,796,764	2,016,391	844,782	
1890	2,997,927	2,289,017	2,845,171	880,264	
1891	2,511,395	1,824,552	1,834,747	891,539	
1892	2,680,194	2,259,367	2,967,678	1,158,072	4,245
1893	1,832,750	1,460,646	1,328,591	817,458	621,047
1894	2,058,683	1,139,273	1,810,290	948,514	1,792,172
1895	2,095,166	1,926,203	2,560,765	1,077,838	2,778,296
1896	2,605,152	1,538,238	1,799,884	1,088,389	2,884,372
1897	2,715,039	1,937,013	2,258,236	1,278,481	4,280,873
1898	3,125,039	2,522,265	2,498,461	1,265,142	4,613,766
1899	3,757,010	3,301,052	2,795,856	1,771,502	6,626,384
1900	3,457,522	3,261,221	2,875,295	1,655,820	7,809,535
1901	3,245,346	3,619,083	2,938,155	1,786,063	9,004,890
1902	3,868,025	4,612,509	3,663,484	2,084,263	13,342,840
1903	3,040,245	3,749,567	2,912,912	1,676,699	12,892,542
1904	2,504,951	3,047,096	2,288,400	1,299,265	12,086,878

VITA

THE author of this dissertation, Henry Raymond Mussey, was born in Atkinson, Illinois, December 7, 1875. He prepared for college at the Geneseo Collegiate Institute, Geneseo, Illinois, and was graduated from Beloit College with the degree of A. B. in 1900. In 1901 he was appointed University Fellow in Economics at Columbia University, in which institution he studied during that and the following year under Professors E. R. A. Seligman, John B. Clark, H. R. Seager, H. L. Moore, F. H. Giddings, James Harvey Robinson and William M. Sloane, attending the seminars of Professors Seligman and Clark. In 1903 he was appointed Instructor and in 1904 Assistant Professor of Economics and Industry in the New York University School of Commerce, Accounts and Finance.

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Sketch Map of the
Lake Superior Iron
District

