Probably the most attractive mining town in the Lake Superior Region is the village of Gwinn, planned and built by the Cleveland Cliffs Iron Co. The only natural advantage is its situation on the Escanaba river which affords good drainage and a sewage outlet. The village is laid out on a beautiful plan with ample parks. A fine commodious school building, an excellent club house for employes of the company and a good hotel are noteworthy features, while the general cleanliness and cheerfulness of appearance of both business and residence portions of the village is indeed refreshing to the visitor as it must be to the residents. The company, whose skill, energy and foresight has created an industry which supports a growing community with modern provisions for human comfort and sanitation where lately was a jack pine sand plain should be commended and congratulated.

GEOLOGY.

The Gwinn district forms a southeastward pitching synclinorium of Upper Huronian rocks about 2 miles long and ½ to ¾ of a mile wide, widening to the southeast where the structure is lost beneath deep overburden. In other directions the district is surrounded by hills of Archean granite.

The Upper Huronian rocks lie unconformably on the Archean granite and comprise two distinct formations, viz., the Goodrich quartzite, which at the base is a recomposed granite or arkose grading upward through quartzite and quartz slate into the Bijiki iron-bearing member, and the Michigamme slate series in which the Bijiki formation is included. The Goodrich quartzite is absent in places thus bringing the slate or iron formation into contact with the underlying granite.

Flat lying Paleozoic limestones and sandstones overlap to the east, the older formations of the Gwinn district. (See fig. 10.)

ORE RESERVES.

The ore reserves of the district as reported to the State Tax Commission by J. R. Finlay in 1911 are given below:

Probably the most attractive mining town in the Lake Superior Region is the village of Gwinn, planned and built by the Cleveland Cliffs Iron Co. The only natural advantage is its situation on the Escanaba river which affords good drainage and a sewage outlet.

ORE RESERVES.

The ore reserves of the district as reported to the State Tax Commission by J. R. Finlay in 1911 are given below:

ORE RESERVES, GWINN DISTRICT, 1911.

Mine.	Reported in sight above bottom level.	Total tonnage expected by J. R. Finlay.
Stegmiller	246,000	266,000
Princeton No. 1 and No. 2	1,157,317	1,057,000
Austin	503,774	503,774
Stephenson	780,646	780,646
Smith	952,727	952,727
Sec. 19, 45-25 N. E. ¼ of N. E. ¼	....	54,143
Sec. -25 lots 2 and 3	....	523,339
Sec. 27, 45-25 S. W. ¼ and S. W. ¼ of N. W. ¼	....	345,203
Kidder	....	646,071
Sec. 29, 45-25 N. ½ of N. W. ¼	....	246,800
Sec. 35, 45-25 S. E. ¼ of S. E. ¼	....	453,425
Sec. 35, 45-25	....	916,130
	3,640,464	6,746,158

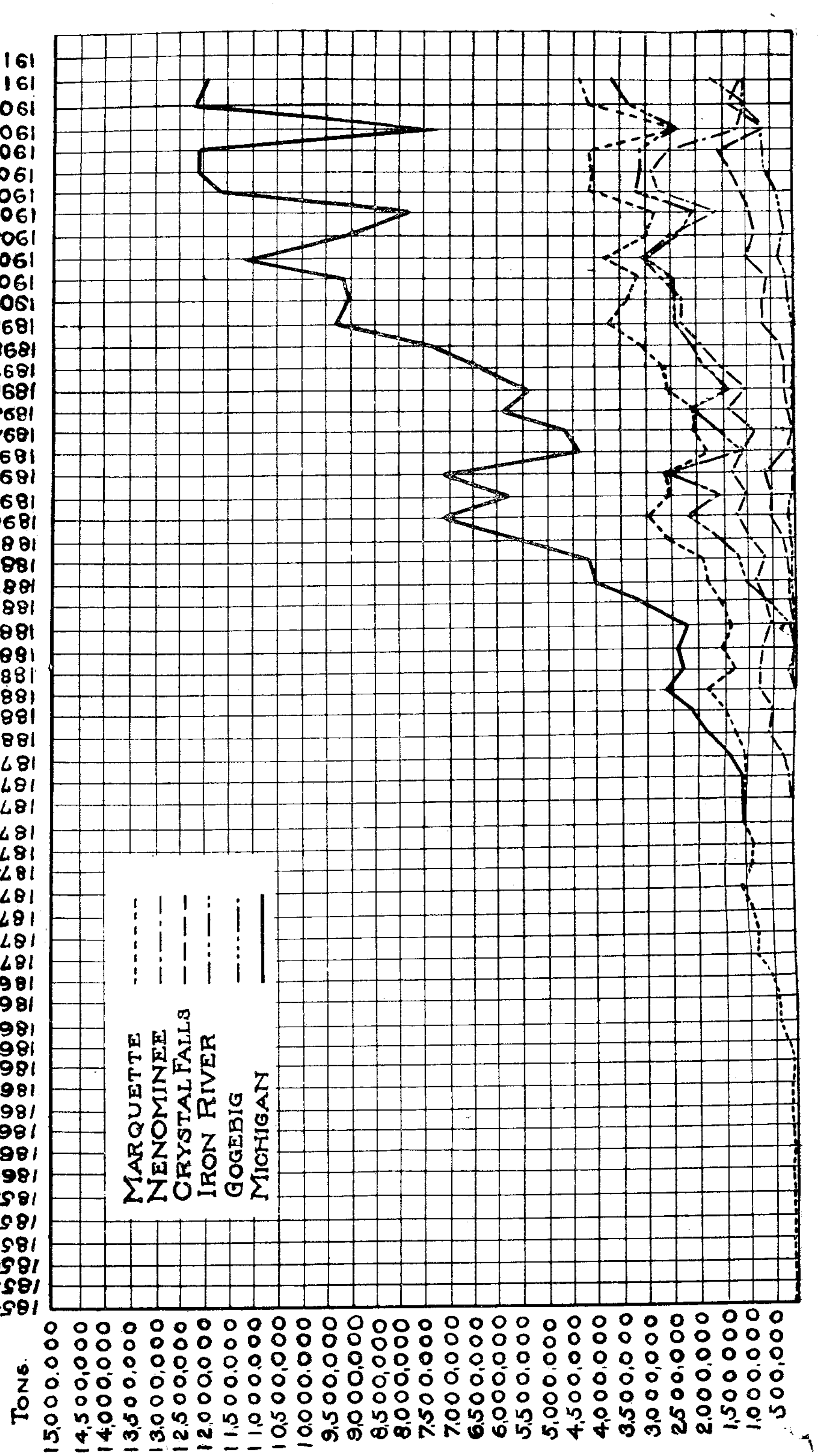

Fig. 11. Production curves for Michigan Iron Ranges.

SUMMARY OF IRON ORE SHIPMENTS FROM MICHIGAN RANGES. (GROSS TONS)

Range.	1880 and prior years.	1881.	1882.	1883.	1884.
Marquette	13,849,627	1,564,823	1,797,896	1,291,695	1,554,477
Gwinn	79,840	15,011	31,498	13,730	3,557
Menominee	943,535	541,724	756,594	712,150	663,425
Crystal Falls			42,111	70,866	66,175
Iron River			31,595	129,590	90,204
Gogebic					1,022
Metropolitan			23,854	43,845	37,581
Calumet			5,847	29,239	3,627
Total	14,873,002	2,121,558	2,689,395	2,291,115	2,420,068
	1885.	1886.	1887.	1888.	1889.
Marquette	1,430,362	1,619,052	1,848,792	1,923,667	2,642,813
Gwinn		8,328	2,142		
Menominee	567,805	592,443	786,244	637,182	947,124
Crystal Falls	23,990	185,680	172,665	230,282	314,229
Iron River	55,693	86,366	116,006	115,744	180,340
Gogebic	114,393	658,951	1,069,409	1,249,415	1,575,989
Metropolitan		6,393	9,070	3,490	
Calumet					
Total	2,192,243	3,157,213	4,004,328	4,159,780	5,660,495
	1890.	1891.	1892.	1893.	1894.
Marquette	2,993,663	2,504,941	2,637,453	1,816,797	2,060,260
Gwinn		7,301	29,403	19,096	
Menominee	1,233,700	1,053,772	1,338,659	1,128,238	866,804
Crystal Falls	527,038	504,928	603,048	220,969	37,515
Iron River	159,494	81,082	46,921	3,917	
Gogebic	2,230,395	1,601,266	2,510,945	1,228,138	1,668,729
Metropolitan		1,049			
Calumet					
Total	7,144,290	5,754,339	7,166,429	4,417,155	4,633,308
	1895.	1896.	1897.	1898.	1899.
Marquette	2,091,245	2,604,221	2,715,035	3,099,792	3,701,208
Gwinn	6,593			25,247	55,802
Menominee	1,471,543	1,139,996	1,516,004	1,816,638	2,348,205
Crystal Falls	202,600	288,209	284,986	356,268	716,971
Iron River	17,955	3,419	146	5,009	44,346
Gogebic	2,126,090	1,434,006	1,865,130	2,072,356	2,441,053
Metropolitan					
Calumet					
Total	5,916,026	$5,469,851	6,381,301	7,375,310	9,307,585

SUMMARY OF IRON ORE SHIPMENTS FROM MICHIGAN RANGES. (GROSS TONS)

(Continued.)

	1900.	1901.	1902.	1903.	1904.
Marquette	3,382,495	3,178,295	3,749,977	2,956,022	2,767,242
Gwinn	75,037	67,051	118,048	84,223	76,461
Menominee	2,312,779	2,660,030	3,001,189	2,528,819	1,712,800
Crystal Falls	720,066	696,844	1,003,785	824,461	917,969
Iron River	139,278	157,541	355,110	276,785	284,273
Gogebic	2,422,454	2,419,144	3,018,255	2,465,263	2,042,398
Metropolitan	....	11,444	8,923	18,574	4,737
Calumet	....	....	....	....	....
Total	9,072,109	9,190,349	11,255,287	9,154,147	7,805,880

	1905.	1906.	1907.	1908.	1909.
Marquette	4,086,493	3,935,293	3,907,955	2,214,782	3,983,436
Gwinn	129,079	166,894	380,118	199,850	272,736
Menominee	2,741,169	2,953,131	2,498,784	1,254,110	1,991,108
Crystal Falls	1,174,366	1,395,910	1,631,484	629,602	1,425,261
Iron River	337,973	568,469	589,946	630,745	1,152,076
Gogebic	3,215,352	3,113,981	3,093,083	2,348,626	3,402,415
Metropolitan	....	....	13,913	9,123	24,933
Calumet	....	15,773	51,646	15,222	....
Total	11,684,432	12,149,451	12,166,929	7,302,060	12,251,965

	1910.	Total.
Marquette	3,840,129	93,749,928
Gwinn	552,597	2,419,642
Menominee	1,674,447	46,390,151
Crystal Falls	1,206,592	16,474,870
Iron River	1,001,960	6,661,983
Gogebic	3,652,918	55,061,176
Metropolitan	26,462	243,391
Calumet	....	121,354
Total	11,955,105	221,122,495

SHIPMENTS OF IRON ORE FROM MICHIGAN RANGES BY COUNTIES.
(GROSS TONS.)

County.	1890 and prior years.	1891.	1892.	1893.	1894.
Gogebic	6,899,574	1,601,266	2,510,945	1,228,138	1,668,729
Iron	2,598,068	586,010	649,969	224,886	37,515
Dickinson	8,547,872	1,054,821	1,338,659	1,128,238	866,804
Marquette	32,542,296	2,493,690	2,659,662	1,835,893	2,060,260
Baraga	128,677	18,552	7,194	....	....
Total	50,716,487	5,754,339	7,166,429	4,417,155	4,633,308
	1895.	1896.	1897.	1898.	1899.
Gogebic	2,126,090	1,434,006	1,865,130	2,072,356	2,441,053
Iron	220,555	291,628	285,132	361,277	761,317
Dickinson	1,471,543	1,139,996	1,516,004	1,816,638	2,348,205
Marquette	2,097,838	2,604,221	2,715,035	3,125,039	3,733,775
Baraga	....	....	....	....	23,235
Total	5,916,026	5,469,851	6,381,301	7,375,310	9,307,585
	1900.	1901.	1902.	1903.	1904.
Gogebic	2,442,454	2,419,144	3,018,255	2,465,263	2,042,398
Iron	859,344	854,385	1,358,895	1,101,246	1,202,242
Dickinson	2,312,779	2,671,474	3,010,112	2,547,393	1,717,537
Marquette	3,393,618	3,241,008	3,808,244	2,905,597	2,817,195
Baraga	63,904	4,338	59,781	134,648	26,508
Total	9,072,099	9,190,349	11,255,287	9,154,147	7,805,880
	1905.	1906.	1907.	1908.	1909.
Gogebic	3,215,352	3,113,981	3,093,083	2,348,626	3,402,415
Iron	1,512,339	1,964,379	2,221,430	1,260,347	2,577,337
Dickinson	2,741,169	2,968,904	2,564,343	1,278,455	2,016,041
Marquette	4,175,605	4,097,111	4,154,288	2,305,366	3,888,055
Baraga	39,967	5,076	133,785	109,266	368,117
Total	11,684,432	12,149,451	12,166,929	7,302,060	12,251,965
					1910.
Gogebic					3,652,918
Iron					2,208,552
Dickinson					1,700,909
Marquette					4,236,311
Baraga					156,415
Total					11,955,105

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.[1]

	1884.	1885.	1886.	1887.	1888.
Ada (included in Ironton)					
Anvil				10,075	24,676
Ashland		6,741	74,015	175,563	174,183
Aurora		5,422	94,553	159,253	179,937
Bessemer			4,788	16,101	
Blue Jacket				1,799	
Brotherton			8,880	21,721	40,639
Castile					
Chicago					
Colby	1,022	84,303	257,432	258,518	285,880
Davis (Wisconsin)					
Eureka					
Federal					
First National				1,997	
Geneva					
Imperial (see Federal)					
Iron Chief			9,950	2,249	
Iron Chief No. 2			551		
Iron King (see Newport)					
Ironton			18,424	24,762	
Jack Pot					
Meteor (Comet)					
Mikado					
New Davis (see Davis)					
Newport			20,184	75,660	69,145
Norrie Group		15,419	124,844	237,254	412,196
Pabst		1,103	17,979	19,906	49,976
Palms				1,414	9,725
Pike					
Puritan (Ruby)			16,388	45,000	3,058
Sparta					
Sunday Lake		1,405	10,963	18,137	
Tilden					
Vaughn (see Aurora)					
Wisconsin (see Davis)					
Yale (West Colby)					
Total	1,022	114,393	658,951	1,069,409	1,249,415

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1889.	1890.	1891.	1892.	1893.
Ada (included in Ironton)					
Anvil	47,000	73	42,090		
Ashland	257,915	435,949	267,439	231,896	66,067
Aurora	199,865	246,695	83,554	319,482	179,028
Bessemer					
Blue Jacket					
Brotherton	53,267	80,486	46,574	130,833	18,905
Castile					
Chicago					
Colby	136,833	193,038	9,619	69,968	59,346
Davis (Wisconsin)		1,497		21,754	15,210
Eureka		23,794	13,907	10,655	31,385
Federal		21,150	6,778	8,515	
First National					
Geneva					
Imperial (see Federal)					
Iron Chief					
Iron Chief No. 2					
Iron King (see Newport)					
Ironton	8,635	6,247	300		
Jack Pot				3,944	1,651
Meteor (Comet)		2,882	10,144	54,779	9,604
Mikado					
New Davis (see Davis)					
Newport	36,987	71,488	105,606	165,962	109,718
Norrie Group	674,394	906,728	758,572	985,216	472,062
Pabst	116,376	172,060	130,226	113,245	104,510
Palms	35,245	50,604	32,227	102,382	2,658
Pike					
Puritan (Ruby)	9,472	11,694	913		
Sparta				2,912	
Sunday Lake		6,010	64,902	56,046	22,876
Tilden			28,415	233,356	135,118
Vaughn (see Aurora)					
Wisconsin (see Davis)					
Yale (West Colby)					
Total	1,575,989	2,230,395	1,601,266	2,510,945	1,228,138

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1894.	1895.	1896.	1897.	1898.
Ada (included in Ironton)					
Anvil	13,297	68,064	57,483		5,037
Ashland	83,020	126,096	91,149	111,625	123,208
Aurora	203,152	245,883	187,169	166,122	133,076
Bessemer					
Blue Jacket					
Brotherton	47,148	40,567	50,490	46,186	73,198
Castile					
Chicago			504		
Colby	32,616		48,492	22,921	152,875
Davis (Wisconsin)		10,253			
Eureka	18,329	26,105	4,544		
Federal					
First National					
Geneva					
Imperial (see Federal)					
Iron Chief					
Iron Chief No. 2					
Iron King (see Newport)					
Ironton					
Jack Pot				1,265	
Meteor (Comet)	11,782				
Mikado		4,788		11,397	
New Davis (see Davis)					
Newport	150,392	157,821	142,369	150,979	196,953
Norrie Group	621,608	738,480	329,068	604,281	700,990
Pabst	206,074	219,960	68,984	220,496	223,891
Palms	37,911	46,965	114,108	207,153	175,925
Pike					
Puritan (Ruby)					
Sparta		1,950			
Sunday Lake	34,323	20,970	89,441	45,815	
Tilden	209,077	418,188	250,205	276,890	287,203
Vaughn (see Aurora)					
Wisconsin (see Davis)					
Yale (West Colby)					
Total	1,668,729	2,126,090	1,434,006	1,865,130	2,072,356

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1899.	1900.	1901.	1902.	1903.
Ada (included in Ironton)					
Anvil			101	135,502	11,309
Ashland	154,615	232,961	286,399	301,824	274,138
Aurora	170,369	193,111	223,747	402,981	355,365
Bessemer					
Blue Jacket					
Brotherton	78,858	89,804	103,109	53,255	94,986
Castile					
Chicago		633		44,625	22,965
Colby	103,239	32,572	23,475	22,526	54,915
Davis (Wisconsin)	5,029	3,569		31,530	734
Eureka					
Federal					
First National					
Geneva					7,108
Imperial (see Federal)					
Iron Chief					
Iron Chief No. 2					
Iron King (see Newport)					
Ironton	7,977	25,047		8,555	16,875
Jack Pot		33,893	19,988	102	31,709
Meteor (Comet)	332	7,844	34,140	19,117	6,156
Mikado	10,324	1,090	91,846	98,834	108,709
New Davis (see Davis)					
Newport	263,711	217,201	190,448	141,571	279,905
Norrie Group	714,669	666,389	660,965	1,080,032	790,346
Pabst	263,869	239,242	198,686		
Palms	154,705	139,658	7,603	32,113	60,800
Pike		3,434	6,346	6,343	115
Puritan (Ruby)			21,788		
Sparta					
Sunday Lake	12,526	74,097	89,997	144,630	91,383
Tilden	500,830	481,909	446,670	468,672	211,534
Vaughn (see Aurora)					
Wisconsin (see Davis)					
Yale (West Colby)			12,836	26,043	46,211
Total	2,441,053	2,442,454	2,419,144	3,018,255	2,465,263

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1904.	1905.	1906.	1907.	1908.	1909.	1910.	Total.
Ada (included in Ironton)	....	....	....	....	....	....	....	....
Anvil	45,595	82,118	79,493	39,495	35,937	22,927	7,235	728,507
Ashland	344,102	409,131	341,841	298,056	259,611	259,612	231,506	5,618,662
Aurora	212,920	....	....	....	....	....	....	3,961,684
Bessemer	....	....	....	....	....	....	....	20,889
Blue Jacket	....	....	....	....	....	....	....	1,799
Brotherton	84,870	137,351	147,281	104,224	96,776	103,090	102,626	1,855,124
Castile	....	....	2,108	6,157	....	26,982	20,197	55,444
Chicago	....	....	....	....	....	....	....	68,727
Colby	81,141	83,736	113,001	94,480	58,305	170,095	194,754	2,645,102
Davis (Wisconsin)	11,225	3,160	....	....	....	....	....	103,961
Eureka	....	....	37,525	57,904	122,324	115,662	41,611	503,745
Federal	....	....	....	....	....	....	....	36,443
First National	....	....	....	....	....	....	....	1,997
Geneva	....	....	....	....	....	....	....	7,108
Imperial (see Federal)	....	....	....	....	....	....	....	....
Iron Chief	....	....	....	....	....	....	....	12,199
Iron Chief No. 2	....	....	....	....	....	....	....	551
Iron King (see Newport)	....	....	....	....	....	....	....	....
Ironton	23,197	41,314	106,158	190,968	92,932	277,594	109,025	958,910
Jack Pot	6,538	....	....	....	....	....	....	99,090
Meteor (Comet)	59,589	....	....	....	....	....	....	216,367
Mikado	25,611	140,740	154,043	163,891	86,617	99,195	52,715	1,049,800
New Davis (see Davis)	....	....	....	....	....	....	....	....
Newport	171,931	438,023	549,745	551,496	579,390	1,008,354	1,182,324	7,027,363
Norrie Group	618,638	1,527,128	1,245,997	1,109,085	773,243	977,054	1,333,006	19,077,664
Pabst	....	....	....	....	....	....	....	2,366,583
Palms	53,718	13,953	5,622	....	....	....	....	1,284,489
Pike	....	11,161	17,934	24,922	6,303	22,174	3,324	102,056
Puritan (Ruby)	1,259	....	....	....	....	....	50,019	159,591
Sparta	....	....	....	....	....	....	....	4,862
Sunday Lake	50,625	79,209	86,879	101,899	111,130	93,712	115,486	1,422,461
Tilden	204,581	188,104	169,697	312,496	111,184	154,506	99,937	5,188,572
Vaughn (see Aurora)	....	....	....	....	....	....	....	....
Wisconsin (see Davis)	....	....	....	....	....	....	....	....
Yale (West Colby)	46,860	60,224	56,657	38,010	14,874	71,458	108,253	481,426
Total	2,042,398	3,215,352	3,113,981	3,093,083	2,348,626	3,402,415	3,652,918	55,061,176

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.[1]

	1877.	1878.	1879.	1880.	1881.
Antoine	....	....	....	....	....
Aragon	....	....	....	....	....
Breen	5,812	4,796	1,463	5,359	....
Briar Hill	....	....	....	....	....
Chapin	....	....	....	34,556	134,521
Clifford	....	....	....	....	....
Cornell	....	....	....	30,856	11,816
Cuff	....	....	....	....	....
Cundy	....	....	....	....	....
Curry	....	....	12,803	21,851	17,534
Cyclops	....	6,028	46,158	14,368	12,644
Eleanor (Appleton)	....	....	....	....	....
Emmett	....	12,397	22,474	31,136	648
Forest	....	....	....	....	....
Half and Half	....	....	....	....	....
Hamilton	....	....	....	....	....
Hersel	....	....	....	....	....
Indiana	....	....	....	....	....
Keel Ridge	....	....	....	11,496	19,511
Loretto	....	....	....	....	....
Ludington	....	....	....	8,816	3,374
Millie (Hewitt)	....	....	....	....	4,352
Munro	....	....	....	....	....
Norway	....	7,276	73,519	198,165	137,077
Penn Iron Mining Co	....	....	....	....	....
Perry	....	....	....	....	....
Pewabec	....	....	....	....	....
Quinnesec	....	25,925	41,954	52,436	43,711
Saginaw (Perkins)	....	....	13,465	49,196	60,406
Stephenson	....	....	798	23,089	10,856
Sturgeon River	....	....	....	....	....
Verona	....	....	....	....	....
Vivian	....	....	....	....	....
Vulcan	4,593	38,799	56,975	86,976	85,274
Walpole	....	....	....	....	....
Total	10,405	95,221	269,609	568,300	541,724
METROPOLITAN TROUGH.					
Groveland	....	....	....	....	....
Metropolitan	....	....	....	....	....
Northwestern	....	....	....	....	....
Total	....	....	....	....	....
CALUMET TROUGH.					
Calumet	....	....	....	....	....

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1882.	1883.	1884.	1885.	1886.
Antoine	....	....	....	....	....
Aragon	....	....	....	....	....
Breen	....	....	....	....	....
Briar Hill	10,593	4,388	....	....	....
Chapin	247,506	265,830	290,972	157,455	198,871
Clifford	....	....	....	....	....
Cornell	....	....	....	....	4,566
Cuff	....	....	....	....	....
Cundy	....	....	....	....	....
Curry	13,374	3,676	10,079	4,897	....
Cyclops	18,287	22,675	24,099	49,897	37,189
Eleanor (Appleton)	....	....	....	....	....
Emmett	....	....	....	....	....
Forest	....	....	....	....	....
Half and Half	....	....	....	....	....
Hamilton	....	....	....	....	872
Hersel	....	....	....	....	....
Indiana	4,280	4,362	636	2,739	5,854
Keel Ridge	23,425	5,033	....	....	....
Loretto	....	....	....	....	....
Ludington	52,152	102,632	101,165	124,194	74,454
Millie (Hewitt)	9,500	7,516	7,927	4,627	5,517
Munro	....	....	....	....	....
Norway	165,547	114,836	71,710	67,741	93,878
Penn Iron Mining Co	....	....	....	....	....
Perry	....	3,138	....	....	....
Pewabec	....	....	....	....	....
Quinnesec	44,240	21,676	16,995	14,110	13,442
Saginaw (Perkins)	73,648	76,514	38,120	18,020	12,852
Stephenson	....	....	....	....	1,018
Sturgeon River	....	....	....	....	....
Verona	....	....	....	....	....
Vivian	....	....	....	....	....
Vulcan	94,042	79,874	101,722	124,125	143,930
Walpole	....	....	....	....	....
Total	756,594	712,150	663,425	567,805	592,443
METROPOLITAN TROUGH.					
Groveland	....	....	....	....	....
Metropolitan	23,854	36,643	27,577	....	6,393
Northwestern	....	7,202	10,004	....	....
Total	23,854	43,845	37,581	....	6,393
CALUMET TROUGH.					
Calumet	5,847	29,239	3,627	....	....

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1887.	1888.	1889.	1890.	1891.
Antoine					
Aragon			1,745	46,609	96,829
Breen					
Briar Hill					
Chapin	336,128	290,871	518,990	742,843	488,749
Clifford					
Cornell	2,064				
Cuff					
Cundy					
Curry		5,376	28,722	72,162	100,681
Cyclops	14,297	14,693	6,101	7,361	10,599
Eleanor (Appleton)					
Emmett					
Forest					
Half and Half			5,961	1,496	67
Hamilton	600	8,801	8,347	17,072	58,197
Hersel				955	
Indiana					
Keel Ridge					
Loretto					
Ludington	101,653	61,883	116,297	97,355	141,303
Millie (Hewitt)	1,163	11,124	12,274	39,232	5,889
Munro					
Norway	95,726	87,260	68,044	61,717	4,089
Penn Iron Mining Co					
Perry					
Pewabec				26,991	64,507
Quinnesec	6,585	2,249			
Saginaw (Perkins)	10,834	16,684	12,354	11,971	
Stephenson	3,589				
Sturgeon River	6,827	7,800	4,775		
Verona					
Vivian					
Vulcan	205,036	129,541	153,900	104,996	78,967
Walpole	1,740	900	9,614	2,940	3,895
Total	786,244	637,182	947,124	1,233,700	1,053,772
METROPOLITAN TROUGH.					
Groveland					1,049
Metropolitan	9,070	3,490			
Northwestern					
Total	9,070	3,490			1,049
CALUMET TROUGH.					
Calumet					

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1892.	1893.	1894.	1895.	1896.
Antoine				27,931	110,821
Aragon	167,948	127,901	138,209	183,296	95,809
Breen					
Briar Hill					
Chapin	660,052	489,134	235,895	218,589	420,318
Clifford					
Cornell					
Cuff					
Cundy					3,395
Curry	125,773				
Cyclops	1,697				
Eleanor (Appleton)	4,377	5,618		2,107	
Emmett					
Forest					
Half and Half					
Hamilton	2,183				
Hersel					
Indiana					
Keel Ridge	5,997	3,298		19,441	
Loretto	8,131	55,983		53,160	34,334
Ludington	15,777	109	354		
Millie (Hewitt)	6,780		13,062	10,924	21,815
Munro					
Norway	44,767				
Penn Iron Mining Co		280,450	175,274	290,622	179,917
Perry					
Pewabec	115,273	165,745	303,010	262,551	273,587
Quinnesec				761	
Saginaw (Perkins)				2,161	
Stephenson					
Sturgeon River					
Verona					
Vivian					
Vulcan	179,904				
Walpole					
Total	1,338,659	1,128,238	866,804	1,471,543	1,139,996
METROPOLITAN TROUGH.					
Groveland					
Metropolitan					
Northwestern					
Total					
CALUMET TROUGH.					
Calumet					

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1897.	1898.	1899.	1900.	1901.
Antoine	98,847	104,510	93,025	119,940	63,429
Aragon	149,594	295,821	337,807	404,645	477,212
Breen					
Briar Hill					
Chapin	643,402	724,768	940,513	929,937	929,701
Clifford					
Cornell					
Cuff			20,210	38,209	
Cundy	41,942	76,877	100,902	141,148	178,800
Curry					
Cyclops					
Eleanor (Appleton)					
Emmett					
Forest					
Half and Half					
Hamilton					
Hersel					
Indiana					
Keel Ridge			4,900		
Loretto	54,104	68,447	64,824	61,219	54,985
Ludington					
Millie (Hewitt)	10,374	17,430	15,194	14,922	12,133
Munro					
Norway					
Penn Iron Mining Co	237,886	223,713	229,651	197,606	358,126
Perry					
Pewabec	279,855	305,072	530,129	374,043	507,786
Quinnesec			11,050	25,967	66,383
Saginaw (Perkins)					
Stephenson					
Sturgeon River					
Verona				5,143	11,475
Vivian					
Vulcan					
Walpole					
Total	1,516,004	1,816,638	2,348,205	2,312,779	2,660,030
METROPOLITAN TROUGH.					
Groveland					11,444
Metropolitan					
Northwestern					
Total					11,444
CALUMET TROUGH.					
Calumet					

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1902.	1903.	1904.	1905.	1906.
Antoine	110,993	107,886	81,164	138,395	195,855
Aragon	646,203	522,035	374,944	423,698	431,000
Breen				16,625	21,004
Briar Hill					
Chapin	956,812	704,051	541,324	902,628	943,425
Clifford					
Cornell					
Cuff					
Cundy	183,052	111,851			
Curry					
Cyclops					
Eleanor (Appleton)				1,819	3,121
Emmett					
Forest			11,988		
Half and Half					
Hamilton					
Hersel					
Indiana					
Keel Ridge					
Loretto	128,300	87,939	54,720	118,738	140,390
Ludington					
Millie (Hewitt)	25,935	40,860			36,815
Munro		8,739	32,332	92,183	47,454
Norway					
Penn Iron Mining Co	273,443	343,543	141,948	423,244	496,582
Perry					
Pewabec	530,291	489,175	372,791	533,413	493,891
Quinnesec	62,531	49,708	33		
Saginaw (Perkins)					21,017
Stephenson					
Sturgeon River					
Verona	43,245	50,910	20,202		
Vivian	40,384	12,122	81,354	90,426	122,577
Vulcan					
Walpole					
Total	3,001,189	2,528,819	1,712,800	2,741,169	2,953,131
METROPOLITAN TROUGH.					
Groveland	7,599	1,294	4,737		
Metropolitan					
Northwestern	1,324	17,280			
Total	8,923	18,574	4,737		
CALUMET TROUGH.					
Calumet					15,773

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1907.	1908.	1909.	1910.	Total.
Antoine	100,996	...	...	...	1,353,792
Aragon	441,636	226,354	246,984	241,046	6,077,325
Breen	20,366	...	...	...	75,425
Briar Hill	...	...	...	...	14,981
Chapin	855,308	391,620	587,647	465,543	16,647,959
Clifford	...	...	103,626	91,081	194,707
Cornell	...	...	...	...	49,302
Cuff	...	...	...	...	58,419
Cundy	...	1,410	5,512	...	844,889
Curry	...	...	...	...	416,928
Cyclops	...	...	...	...	286,093
Eleanor (Appleton)	1,677	...	...	...	18,719
Emmett	...	...	...	...	66,655
Forest	...	...	...	...	11,988
Half and Half	...	...	...	...	7,524
Hamilton	...	...	...	...	96,072
Hersel	...	...	...	...	955
Indiana	...	...	...	...	17,871
Keel Ridge	...	...	...	...	93,101
Loretto	99,779	13,354	96,613	116,048	1,311,068
Ludington	...	...	...	...	1,001,518
Millie (Hewitt)	18,691	3,322	10,887	...	368,265
Munro	46,834	27,773	23,241	20,022	298,578
Norway	...	...	...	...	1,291,352
Penn Iron Mining Co	381,128	176,211	428,004	344,760	5,182,108
Perry	...	...	...	...	3,138
Pewabec	457,796	365,341	465,453	380,376	7,298,076
Quinnesec	...	...	3,147	744	503,647
Saginaw (Perkins)	26,080	38,669	19,994	...	501,985
Stephenson	...	...	...	...	39,350
Sturgeon River	...	...	...	...	19,404
Verona	...	...	...	...	130,975
Vivian	48,493	10,056	...	14,827	420,239
Vulcan	...	...	...	...	1,668,654
Walpole	...	...	...	...	19,089
Total	2,498,784	1,254,110	1,991,108	1,674,447	46,390,151
METROPOLITAN TROUGH.					
Groveland	13,913	9,123	24,933	26,462	100,554
Metropolitan	...	...	...	...	107,027
Northwestern	...	...	...	...	35,810
Total	13,913	9,123	24,933	26,462	243,391
CALUMET TROUGH.					
Calumet	51,646	15,222	...	...	121,354

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN [1]

	1882.	1883.	1884.	1885.	1886.
Baker	...	...	...	...	...
Baltic	...	...	...	...	...
Berkshire	...	...	...	...	...
Beta	...	...	...	...	1,585
Caspian	...	...	...	...	...
Chatham	...	...	...	...	...
Davidson No. 1	...	...	...	...	...
Davidson No. 2	...	...	...	...	...
Chicagon	...	...	...	...	...
Fogarty	...	...	...	...	...
Hiawatha	...	...	...	...	...
Iron River	29,115	100,369	52,584	55,693	78,591
James (Osana)	...	...	...	...	...
Dober	...	...	...	...	...
Nanaimo	2,480	29,221	37,620	...	5,400
Riverton	...	...	...	...	...
Selden	...	...	...	...	790
Sheridan	...	...	...	...	...
Tully	...	...	...	...	...
Youngs	...	...	...	...	...
Zimmerman	...	...	...	...	...
Total	31,595	129,590	90,204	55,693	86,366
	1887.	**1888.**	**1889.**	**1890.**	**1891.**
Baker	...	...	...	...	...
Baltic	...	...	...	...	...
Berkshire	...	...	...	...	...
Beta	1,226	...	...	...	1,400
Caspian	...	...	...	...	...
Chatham	...	...	...	...	...
Davidson No. 1	...	...	...	...	...
Davidson No. 2	...	...	...	...	...
Chicagon	...	...	...	...	...
Fogarty	...	...	...	...	...
Hiawatha	...	...	...	...	...
Iron River	83,018	110,000	179,238	155,458	59,345
James (Osana)	...	...	...	...	...
Dober	...	...	...	...	...
Nanaimo	30,460	5,744	...	3,441	13,200
Riverton	...	...	...	...	...
Selden	1,302	...	...	...	...
Sheridan	...	...	1,102	595	7,137
Tully	...	...	...	...	...
Youngs	...	...	...	...	...
Zimmerman	...	...	...	...	...
Total	116,006	115,744	180,340	159,494	81,082

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.

	1892.	1893.	1894.	1895.	1896.
Baker					
Baltic					
Berkshire					
Beta					
Caspian					
Chatham					
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty					
Hiawatha		1,683		1,201	
Iron River	1,176				
James (Osana)					
Dober					
Nanaimo					
Riverton					
Selden					
Sheridan	45,744	2,234		16,754	3,419
Tully					
Youngs					
Zimmerman					
Total	46,921	3,917		17,955	3,419

	1897.	1898.	1899.	1900.	1901.
Baker					
Baltic					17,326
Berkshire					
Beta					
Caspian					
Chatham					
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty					
Hiawatha				11,008	20,355
Iron River					
James (Osana)					
Dober		5,009	10,980	49,203	
Nanaimo					
Riverton			2,262	71,004	119,860
Selden					
Sheridan	146		31,104	8,063	
Tully					
Youngs					
Zimmerman					
Total	146	5,009	44,346	139,278	157,541

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.

	1902.	1903.	1904.	1905.	1906.
Baker					
Baltic	64,664	123,236	151,114	133,246	186,495
Berkshire					
Beta					
Caspian		2,088	4,242	10,248	80,875
Chatham					
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty					
Hiawatha	74,596	53,828	38,288	9,704	20
Iron River					
James (Osana)					
Dober					
Nanaimo			9,086	91,238	91,792
Riverton	215,850	97,633	81,543	82,611	161,704
Selden					
Sheridan					
Tully					
Youngs				10,926	47,583
Zimmerman					
Total	355,110	276,785	284,273	337,973	568,469

	1907.	1908.	1909.	1910.	Total.
Baker			45,003	39,417	84,420
Baltic	189,119	129,037	174,426	171,930	1,340,593
Berkshire		3,440	34,295	97,999	135,734
Beta					4,211
Caspian	138,867	102,628	189,023	171,334	699,305
Chatham	14,883	45,826	68,730	51,988	181,427
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty	7,949	32,560	77,356	51,071	168,936
Hiawatha		138,190	136,739	128,884	614,496
Iron River					904,587
James (Osana)	2,360	59,760	90,851	78,388	231,359
Dober					65,192
Nanaimo	53,778	305			373,765
Riverton	90,358	47,073	171,200	84,269	1,225,367
Selden					2,092
Sheridan					116,299
Tully				2,726	2,726
Youngs	92,632	70,094	154,150	98,399	473,784
Zimmerman		1,832	10,303	25,555	37,690
Total	589,946	630,745	1,152,076	1,001,960	6,661,983

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.[1]

	1882.	1883.	1884.	1885.	1886.
Alpha					
Armenia					50,275
Bristol (Claire)					
Columbia	15,948	4,334	6,774		14,282
Crystal Falls	1,341				
Delphic		3,410	508	9,880	17,648
Dunn					
Fairbanks	8,045	455			
Genesee (Ethel)					
Gibson					
Great Western	587	22,825	20,710		22,267
Hemlock					
Hilltop					
Hollister					
Hope					
Kimball					
Lamont (Monitor)					
Lee Peck					
Lincoln					
Mangonate					
Mansfield					
Mastodon	3,477	18,577	18,187	11,737	41,640
McDonald					
Michigan					
Monongahela					
Paint River (Fairbanks)	6,515	5,973	11,652	2,373	13,933
Shelden & Shafer (Union) (see Columbia)					
South Mastodon					
Tobin					
Youngstown	6,198	15,292	8,344		25,635
Total	42,111	70,866	66,175	23,990	185,680

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1887.	1888.	1889.	1890.	1891.
Alpha					
Armenia	26,649				
Bristol (Claire)					
Columbia	2,377	10,936	11,385	60,133	70,770
Crystal Falls				3,974	
Delphic	2,272				
Dunn	24,677	118,096	151,826	156,963	162,721
Fairbanks					
Genesee (Ethel)					
Gibson					
Great Western	23,239	21,860	38,454	72,546	62,464
Hemlock					35,531
Hilltop					
Hollister				2,020	1,057
Hope					
Kimball					
Lamont (Monitor)			12,348	31,139	26,226
Lee Peck					
Lincoln					1,813
Mangonate				6,844	
Mansfield				18,303	49,836
Mastodon	48,792	51,463	63,511	66,526	45,370
McDonald					
Michigan					
Monongahela					
Paint River (Fairbanks)	10,240	12,506	32,700	62,654	45,435
Shelden & Shafer (Union) (see Columbia)					
South Mastodon		2,722	4,005	1,476	
Tobin					
Youngstown	34,418	12,699		44,460	3,705
Total	172,665	230,282	314,229	527,038	504,928

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1892.	1893.	1894.	1895.	1896.
Alpha	....	....	....	....	....
Armenia	....	....	....	2,045	....
Bristol (Claire)	57,352	9,612	....	....	....
Columbia	57,682	22,426	10,300	70,867	87,202
Crystal Falls	....	....	....	13,037	44,526
Delphic	....	....	....	....	52
Dunn	133,666	58,590	24,538	90,885	47,081
Fairbanks	....	....	....	....	....
Genesee (Ethel)	....	....	....	....	....
Gibson	16,357	....	....	....	....
Great Western	87,487	661	....	....	14,643
Hemlock	65,459	11,323	....	949	94,645
Hilltop	....	....	....	....	....
Hollister	1,021	....	....	....	....
Hope	15,543	2,275	....	....	....
Kimball	....	....	....	....	....
Lamont (Monitor)	42,819	13,777	2,600	....	....
Lee Peck	2,844	....	....	....	....
Lincoln	26,019	8,757	....	....	....
Mangonate	....	....	....	....	....
Mansfield	69,259	69,558	....	....	....
Mastodon	9,150	23,485	....	23,733	60
McDonald	....	....	....	....	....
Michigan	....	505	77	1,071	....
Monongahela	....	....	....	....	....
Paint River (Fairbanks)	18,390	....	....	....	....
Shelden & Shafer (Union) (see Columbia)	....	....	....	....	....
South Mastodon	....	....	....	....	....
Tobin	....	....	....	....	....
Youngstown	....	....	....	13	....
Total	603,048	220,969	37,515	202,600	288,209

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1897.	1898.	1899.	1900.	1901.
Alpha	....	....	....	....	....
Armenia	....	....	....	....	18,750
Bristol (Claire)	....	....	80,915	51,639	36,593
Columbia	24,623	14,199	126,290	97,531	19,963
Crystal Falls	95,210	128,233	147,346	197,770	230,614
Delphic	....	....	....	....	....
Dunn	31,062	49,381	7,458	....	....
Fairbanks	....	....	....	....	....
Genesee (Ethel)	....	....	....	....	....
Gibson	....	....	....	....	....
Great Western	....	33,851	43,316	98,550	123,261
Hemlock	96,032	69,865	110,269	72,413	149,966
Hilltop	....	....	3,496	6,410	2,503
Hollister	....	....	....	....	....
Hope	....	....	....	....	....
Kimball	....	....	....	....	....
Lamont (Monitor)	....	....	67,652	31,323	....
Lee Peck	....	....	....	....	....
Lincoln	....	....	43,622	72,959	19,727
Mangonate	....	....	....	....	....
Mansfield	37,182	60,739	86,607	90,155	74,113
Mastodon	....	....	....	....	....
McDonald	....	....	....	....	....
Michigan	216	....	....	....	....
Monongahela	....	....	....	....	2,397
Paint River (Fairbanks)	....	....	....	1,316	....
Shelden & Shafer (Union) (see Columbia)	....	....	....	....	....
South Mastodon	....	....	....	....	....
Tobin	....	....	....	....	18,957
Youngstown	661	....	....	....	....
Total	284,986	356,268	716,971	720,066	696,844

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1902.	1903.	1904.	1905.	1906.
Alpha	....	1,370	....	....	....
Armenia	100,864	31,901	16,577	....	27,882
Bristol (Claire)	129,035	246,581	132,420	210,388	298,031
Columbia	186,798	....	....	27,883	....
Crystal Falls	195,555	117,096	180,983	152,255	111,871
Delphic	....	....	....	....	....
Dunn	2,816	5,365	....	21,051	91,476
Fairbanks	....	....	....	....	....
Genesee (Ethel)	14,455	61,694	132,380	77,370	80,971
Gibson	....	....	....	....	....
Great Western	42,470	100,751	68,318	191,265	311,218
Hemlock	123,331	79,420	136,232	124,450	106,437
Hilltop	....	....	....	....	7,820
Hollister	....	....	....	....	....
Hope	3,373	7,339	....	....	....
Kimball	....	....	....	....	....
Lamont (Monitor)	47,267	43,736	29,393	74,991	89,980
Lee Peck	....	....	....	....	....
Lincoln	7,747	15,606	17,577	19,539	5,890
Mangonate	....	....	....	....	....
Mansfield	31,181	51,440	79,163	38,584	....
Mastodon	....	....	....	....	....
McDonald	....	....	....	....	....
Michigan	53,272	....	....	58,088	146
Monongahela	....	6,913	....	....	....
Paint River (Fairbanks)	10,383	9,863	11,257	11,973	28,321
Shelden & Shafer (Union) (see Columbia)	....	....	....	....	....
South Mastodon	....	....	....	....	....
Tobin	55,238	45,386	113,669	166,529	235,867
Youngstown	....	....	....	....	....
Total	1,003,785	824,461	917,969	1,174,366	1,395,910

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.[1]

	1907.	1908.	1909.	1910.	Total.
Alpha	....	....	....	....	1,370
Armenia	36,665	....	....	65,473	377,081
Bristol (Claire)	345,676	190,300	396,825	270,742	2,456,109
Columbia	....	....	....	....	942,703
Crystal Falls	114,158	296	986	....	1,735,251
Delphic	....	....	....	....	33,770
Dunn	141,992	8,829	193,396	136,144	1,658,015
Fairbanks	....	....	....	....	8,500
Genesee (Ethel)	38,984	....	65,585	66,185	537,624
Gibson	....	4,548	36,246	45,202	102,353
Great Western	234,492	124,246	112,747	80,709	1,952,937
Hemlock	117,181	83,834	112,481	115,407	1,705,225
Hilltop	....	....	....	....	20,229
Hollister	6,371	10,671	25,842	49,434	96,416
Hope	....	....	....	....	28,530
Kimball	16,224	....	....	....	16,224
Lamont (Monitor)	42,090	....	....	3,183	558,524
Lee Peck	....	....	....	....	2,844
Lincoln	714	....	1,657	....	241,627
Mangonate	....	....	....	....	6,844
Mansfield	183,532	44,633	118,713	114,357	1,217,355
Mastodon	....	....	....	....	425,708
McDonald	....	....	1,114	6,022	7,136
Michigan	39,819	603	....	17,922	171,719
Monongahela	....	....	....	....	9,310
Paint River (Fairbanks)	75,805	....	....	....	371,289
Shelden & Shafer (Union) (see Columbia)	....	....	....	....	....
South Mastodon	....	....	....	....	8,203
Tobin	237,781	161,642	359,668	235,812	1,630,549
Youngstown	....	....	....	....	151,425
Total	1,631,484	629,602	1,425,261	1,206,592	16,474,870

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE GWINN DISTRICT.[1] (GROSS TONS)

	1872.	1873.	1874.	1875.
(Austin) (Princeton) (Swanzy or Chesire) Stegmiller (Stephenson)	13,445	9,328	....	187
Total	13,445	9,328	....	187
	1876	**1877.**	**1878.**	**1879.**
(Austin) (Princeton) (Swanzy or Chesire) Stegmiller (Stephenson)	225	8,444	16,924	17,985
Total	225	8,444	16,924	17,985
	1880.	**1881.**	**1882.**	**1883.**
(Austin) (Princeton) (Swanzy or Chesire) Stegmiller (Stephenson)	13,302	15,011	31,498	13,730
Total	13,302	15,011	31,498	13,730
	1884.	**1885.**	**1886.**	**1887.**
(Austin) (Princeton) (Swanzy or Chesire) Stegmiller (Stephenson)	3,557	....	8,328	2,142
Total	3,557	....	8,328	2,142
	1888.	**1889.**	**1890.**	**1891.**
(Austin) (Princeton) (Swanzy or Chesire) Stegmiller (Stephenson)	....	....	....	7,301
Total	....	....	....	7,301

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE GWINN DISTRICT. (GROSS TONS)

	1892.	1893.	1894.	1895.
(Austin) (Princeton) Swanzy or Chesire) Stegmiller (Stephenson)	29,403	19,096	....	6,593
Total	29,403	19,096	....	6,593
	1896.	**1897.**	**1898.**	**1899.**
(Austin) (Princeton) (Swanzy or Chesire) Stegmiller (Stephenson)	....	....	25,247	55,802
Total	....	....	25,247	55,802
	1900.	**1901.**	**1902.**	**1903.**
(Austin) (Princeton) (Swanzy or Chesire) Stegmiller (Stephenson)	75,037	67,051	118,048	84,223
Total	75,037	67,051	118,048	84,223
	1904.	**1905.**	**1906.**	**1907.**
(Austin)	....	....	....	195,950
(Princeton) (Swanzy or Chesire) Stegmiller	76,461	129,079	166,894	177,863
(Stephenson)	....	....	....	6,305
Total	76,461	129,079	166,894	380,118
	1908.	**1909.**	**1910.**	**Total.**
(Austin)	111,229	125,858	188,588	621,625
(Princeton) (Swanzy or Chesire)	36,033	42,934	89,441	1,360,612
Stegmiller	....	39,869	48,842	88,711
(Stephenson)	52,588	64,075	225,726	348,694
Total	199,850	272,736	552,597	2,419,642

CARGO ANALYSES OF THE IRON ORES SHIPPED FROM THE IRON RIVER, CRYSTAL FALLS AND MENOMINEE DISTRICTS IN 1910.[1]

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Antoine	Clifford	Dried	39.25	.017	41.29	.18	.92	.57	.72	.016	1.00	
		Natural	38.36	.017	40.35							2.28
	Autoine	Dried	38.62	.030	42.13	.15	.95	.59	.75	.017	1.05	
		Natural	37.87	.029	41.31							1.95
Aragon	Granada	Dried	59.79	.061	7.12	.16						
		Natural	55.16	.057	6.57							7.74
	Briar Hill	Dried	54.64	.054	8.09	.29						
		Natural	51.81	.051	7.67							5.18
	Cadiz	Dried	51.16	.054	17.03	.17						
		Natural	47.44	.051	15.80							7.26
Armenia		Dried	57.32	.310	8.86	.54	2.66	1.37	.80	.005	3.20	
		Natural	51.24	.271	7.92							10.60
Baker		Dried	56.64	.348	7.67	.51	1.60	1.93	1.20	.008	4.70	
		Natural	51.68	.318	6.99							8.75
Baltic		Dried	55.60	.456	7.96	.32	3.11	1.57	1.49	.048	4.94	
		Natural	50.32	.413	7.20							9.50
Berkshire		Dried	54.25	.720	10.25	.22	4.52	2.60	2.43	.046	3.05	
		Natural	46.97	.645	9.18							10.44
Breen		Dried	39.00	.016	41.53	.03	.89	.35	.80	.027	.60	
		Natural	37.83	.016	40.28							3.00
Bristol	Bristol	Dried	54.86	.633	6.45	.74	2.83	2.77	1.54	.111	5.26	
		Natural	50.58	.584	5.95							7.80
	Manganate	Dried	50.36	.593	6.90	3.21	3.60	2.17	2.41	.055	7.72	
		Natural	46.52	.548	6.37							7.63
Buckeye (Wis.)		Dried	52.40	.436	10.75	.13	2.75	2.22	2.51	.196	6.50	
		Natural	48.21	.401	9.89							8.00
Calumet		Dried	41.75	.023	34.67	.20	2.23	.72	.96	.009	1.46	
		Natural	39.87	.022	33.11							4.50
Caspian		Dried	55.60	.456	7.96	.32	3.11	1.57	1.49	.048	4.94	
		Natural	50.32	.413	7.20							9.50
Chapin	Chapin	Dried	57.97	.065	6.44	.35						
		Natural	53.82	.060	5.98	.32						7.16
	Ajax	Dried	51.73	.055	14.70	.33						
		Natural	48.20	.052	13.69	.31						6.83
Chatham		Dried	53.94	.328	11.12	.18	2.00	.82	.98	1.39	6.47	
		Natural	50.84	.309	10.48							5.74
*Crystal Falls		Dried	56.70	.616	7.60	.69	1.73	2.35	1.90	.006	3.40	
		Natural	51.78	.562	6.94							8.68
Cyclops and Norway, West Vulcan, Curry and Brier Hill	Cyclops	Dried	60.35	.015	9.77	.07	2.16	.81	1.26	.048		
		Natural	56.11	.014	9.05							7.37
	Vulcan	Dried	53.38	.055	11.72	.01	2.30	.76	1.57	.054		
		Natural	54.68	.051	10.83							7.58
	Jupiter	Dried	41.81	.017	33.32		2.95	.69	.88	.050		
		Natural	39.52	.016	31.35							5.92
	Harper	Dried	59.95	.100	7.33	.11	1.38	1.13	2.27	.033	2.05	
		Natural	56.53	.094	6.91							5.70

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Davidson No. 1*		Dried	56.90	.595	2.88	.35	2.78	.45	.40	.056	10.90	
		Natural	52.63	.550	2.66							7.50
Dunn		Dried	57.10	.590	6.47	.70	1.91	2.58	2.10	.007	3.05	
		Natural	52.45	.542	5.94							8.15
Florence		Dried	54.80	.269	6.43	.18	3.91	2.14	3.01	1.85	4.77	
		Natural	49.31	.242	5.79							10.02
Fogarty		Dried	55.60	.456	7.96	.32	3.11	1.57	1.49	.048	4.94	
		Natural	50.32	.413	7.20							9.50
Genesee		Dried	57.08	.587	7.33	.35	2.12	2.63	2.55	.008	2.88	
		Natural	52.14	.536	6.70							8.65
Great Western	Great Western	Dried	55.00	.517	6.89	.74	2.90	2.98	2.12	.043	3.16	
		Natural	50.41	.474	6.31							8.35
	Basic	Dried	50.50	.420	6.12	.42	4.80	2.57	3.64	2.93	.091	
		Natural	46.28	.385	5.61							8.35
Groveland		Dried	46.35	.039	19.54	1.04	2.06	2.81	3.86	.011	3.86	
		Natural	45.16	.038	19.04							2.56
Hemlock		Dried	52.50	.196	4.42	.40	2.53	5.64	3.68	.016	7.69	
		Natural	51.03	.191	4.30							2.80
James (Osana)		Dried	55.50	.488	8.73	.22	1.13	.46	.22	.017	8.72	
		Natural	51.06	.449	8.03							8.00
Hollister		Dried	54.50	1.021	11.00	1.12	1.53	4.36	.38	.39	1.02	
		Natural	51.23	.960	10.34							6.00
Loretto	Russell	Dried	53.04	.053	10.25	.27	2.82	2.10	3.85	.006	4.42	
		Natural	49.12	.049	9.49							7.40
	Russell Special	Dried	47.40	.059	18.02	.16	2.63	1.35	2.33	.005	3.81	
		Natural	43.89	.055	16.69							7.40
Mansfield		Dried	57.19	.119	5.30	.18						
		Natural	51.63	.108	4.78							9.72
McDonald		Dried	57.00	.100	6.00	.30	2.50					
		Natural										
Michigan		Dried	55.72	.193	10.54	.21						
		Natural	50.71	.175	9.59							9.00
Millie*	Algoma	Dried	58.60	.045	8.30	.17	1.09	2.15	1.98	.041	2.40	
		Natural	56.10	.043	7.95							4.26
	Dory	Dried	40.55	.027	36.25	.15	.82	.98	1.07	.012	2.10	
		Natural	39.94	.027	35.71							1.50
Pewabic	Pewabic	Dried	59.80	.012	10.38	.12	1.04	.74	1.12	.006	1.31	
		Natural										
	Toledo	Dried	48.10	.014	25.78	.09	1.40	.89	1.35	.015	1.79	
		Natural										
	Pewabic Genoa	Dried	38.85	.012	39.34	.07	1.49	.58	1.48	.009	1.48	
		Natural										
	Walpole	Dried	57.30	.074	7.01	.18	1.66	1.99	3.16	.005	3.93	
		Natural	53.11	.0686	6.498							7.31
	Tyrone	Dried	56.65	.030	11.56	.10	.83	1.66	1.75	.007	3.08	
		Natural										

[1] Published by Lake Superior Iron Ore Association.
* Expected Analysis for 1911.

CARGO ANALYSES OF THE IRON ORES SHIPPED FROM THE IRON RIVER, CRYSTAL FALLS AND MENOMINEE DISTRICTS IN 1910

(Concluded.)

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Quinnesec		Dried	40.70	.032	37.40	.07	1.05	1.45	.77	.006	.95	
		Natural	39.40	.031	36.20							3.20
Riverton (Dober)		Dried	56.20	.611	6.12	.21						
		Natural	51.91	.564	5.65							7.64
Tobin		Dried	57.05	.595	6.82	.32	1.69	2.90	2.68	.007	2.83	
		Natural	52.33	.546	6.25							8.28
Tully		Dried	56.72	.516	7.95	.42	1.73	2.09	1.56	.007	4.32	
		Natural	51.67	.470	7.24							8.91
Vivian		Dried	37.60	.016	40.82	.05	1.18	1.15	1.29	.009	1.72	
		Natural	36.47	.016	39.60							3.00
Youngs		Dried	55.40	.336	9.92	.14	3.17	.75	1.01	.068	4.90	
		Natural	51.20	.311	9.17							7.58

AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE FOR 1910.[1]

Mine	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Ashland	Ashland	Dried	58.00	.048	10.35	.28	3.03	.27	.22	.010	2.78	
		Natural	51.85	.043	9.25							10.60
	Globe	Dried	57.85	.103	11.00	.28	2.87	.53	.47	.017	2.20	
		Natural	52.06	.093	9.90							10.00
Atlantic (Wis.)		Dried	59.85	.035	10.15	.33						
		Natural	53.11	.031	9.01							11.25
	Brotherton	Dried	62.20	.027	8.59	.42	.82	.24	.26	.006	.64	
		Natural	56.91	.025	7.86							8.50
	Brotherton No. 2	Dried	61.00	.045	10.30	.42	.82	.24	.26	.006	.64	
		Natural	55.82	.041	9.42							8.50
	Walton	Dried	61.00	.085	10.30	.42	.82	.24	.26	.006	.64	
		Natural	55.82	.078	9.43							8.50
	Cary Empire	Dried	53.20	.056	12.22	4.14	.93	.19	.16	.010	4.62	
		Natural	48.41	.051	11.12							9.00
Cary (Wis.)	Cary Bessemer & Windsor	Dried	57.05	.046	12.80	.82	.96	.17	.19	.010	3.18	
	Kakagon	Dried	55.80	.076	9.67	3.00	1.01	.37	.34	.007	4.54	
	Nimikon	Dried	58.00	.066	11.72	.36	1.15	.42	.33	.013	2.88	
Castile	Castile	Dried	58.02	.045	13.98	.56	.44	.47	.45	.015	1.00	
		Natural	50.76	.039	12.23							12.52
	Medina	Dried	57.35	.125	13.01	.60	.60	.54	.39	.013	1.25	
		Natural	50.10	.109	11.36							12.65
Colby	Colby	Dried	60.05	.049	7.19	.32	1.53	.93	.82	.005	2.96	
		Natural	53.80	.044	6.44							10.40
	Colby No. 2	Dried	59.65	.060	7.53	.38	1.40	1.05	.91	.007	3.09	
		Natural	53.22	.054	6.72							10.78
Eureka	Belmont	Dried	61.50	.055	6.65	.70	1.28	.40	.62	.022	2.10	
		Natural	52.08	.047	5.63							15.31
	Eureka	Dried	62.59	.065	5.76	.83	1.37	.13	.34	.012	1.96	
		Natural	52.81	.055	4.86							15.63
	Ramsay	Dried	61.48	.094	6.72	.63	1.70	.67	.39	.017	1.90	
		Natural	52.10	.080	5.70							15.25
Germania (Wis.)		Dried	55.50	.064	14.85	.27	1.19	.68	.55	.011	2.55	
		Natural	49.59	.057	13.27							10.65
Ironton	Ironton	Dried	60.02	.048	6.98	.36	1.66	.81	.54	.006	3.12	
		Natural	53.69	.043	6.24							10.55
	Ironton No. 2	Dried	59.68	.061	7.85	.35	1.82	.98	.76	.008	2.81	
		Natural	53.20	.054	6.99							10.86
Montreal	Montreal	Dried	63.64	.045	4.20	.38	.92	trace	trace	.004	3.82	
		Natural	57.40	.041	3.79							9.80
	Lawrence	Dried	61.24	.055	6.52	.48	1.67	.35	.16	.010	4.00	
		Natural	54.69	.049	5.82							10.70
Mikado		Dried	58.10	.109	11.03	.90	.87	.73	.37	.008	2.46	
		Natural	49.68	.093	9.43							14.50

[1] Published by the Lake Superior Iron Ore Association.

AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE FOR 1910.[1]

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Newport	Melrose	Dried	61.60	.045	5.98	.34	2.70	.67	.17	.014	2.12	
		Natural	54.45	.040	5.29							11.61
	New Erie No. 1	Dried	56.55	.047	12.61	.32	2.97	.63	.14	.020	1.93	
		Natural	49.77	.041	11.10							11.99
	Montrose	Dried	60.95	.078	6.60	.41	1.63	.35	.56	.033	3.13	
		Natural	54.29	.069	5.88							10.92
	New Era No. 2	Dried	55.95	.080	12.63	.34	3.18	.60	.26	.015	2.67	
		Natural	50.06	.072	11.30							10.52
	Bonnie	Dried	48.35	.047	14.58	6.95	1.02	.20	.95	.023	4.00	
		Natural	44.65	.043	13.46							7.66
Norrie-Aurora	Aurora	Dried	61.48	.035	6.25	.36						
		Natural	54.48	.031	5.54							11.39
	Norrie	Dried	61.63	.034	5.98	.36						
		Natural	54.82	.030	5.32							11.06
	Nordale	Dried	56.26	.044	11.65	.33						
		Natural	50.04	.039	10.36							11.06
	Vaughn	Dried	61.35	.033	6.24	.36						
		Natural	54.11	.029	5.51							11.81
	Norden	Dried	61.57	.088	6.90	.37						
		Natural	54.41	.077	6.10							11.63
Ottawa (Odanoh) (Wis.)	Ottawa	Dried	55.99	.052	8.82	3.37	1.01	.27	.25	.011	5.06	
		Natural	51.10	.047	8.05							8.74
	Ottawa Manganese	Dried	53.79	.055	8.75	5.69	1.06	.18	.32	.009	5.66	
		Natural	49.22	.050	8.01	5.21						8.50
	Ontario	Dried	56.30	.068	9.67	2.36	1.17	.24	.19	.008	5.18	
		Natural	51.63	.062	8.87							8.30
Puritan		Dried	62.76	.048	5.03	.62						
		Natural	54.59	.042	4.37							13.02
Sunday Lake	Sunday Lake	Dried	59.70	.025	12.25	.45	.86	.21	.19	.007	.54	
		Natural	54.33	.023	11.15							9.00
	Earl	Dried	59.00	.085	12.70	.48	.84	.38	.27	.009	.70	
		Natural	54.87	.079	11.81							7.00
Tilden	Tilden	Dried	63.10	.044	3.96	.70						
		Natural	56.36	.039	3.54							10.68
	Rand	Dried	56.79	.042	9.27	1.77						
		Natural	48.84	.036	7.98							14.00
	Norden	Dried	62.37	.120	4.25	.55						
		Natural	54.27	.104	3.70							12.98
	Norden No. 2	Dried	58.23	.094	10.03	.63						
		Natural	51.28	.083	8.84							11.93

[1] Published by the Lake Superior Iron Ore Association.

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AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE FOR 1910.[1]

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
American	American	Dried	57.60	.040	12.34	.04	3.44	.31	.36	.011	1.10	
		Natural	56.42	.039	12.09							2.05
	Alliance	Dried	53.18	.039	17.54	.03	4.14	.25	.48	.022	1.07	
		Natural	52.27	.038	17.24							1.71
Angeline	Angeline Hematite	Dried	65.30	.041	3.79							
		Natural	59.21	.037	3.43							9.32
	South Angeline Hematite	Dried	63.95	.128	4.40							
		Natural	57.50	.115	3.95							10.08
Breitung Hematite No. 1	Foley	Dried	63.27	.017	6.43	.08	1.45	.18	.18	.010	1.50	
		Natural	58.37	.016	5.93							7.74
	Foley No. 2	Dried	54.88	.018	17.85	.08	1.70	.22	.11	.010	1.50	
		Natural	50.45	.017	16.41							8.06
	Breitung Siliceous	Dried	43.20	.018	33.94	.21	1.93	1.21	Trace	.027	.79	
		Natural	40.41	.017	31.75							6.46
	Hematite Siliceous	Dried	43.00	.033	34.00	.84	2.24	1.68	.12	.008	1.58	
		Natural	40.42	.031	31.96							6.00
Breitung Hematite No. 2	Mary	Dried	58.73	.103	8.35	.23	2.98	.62	.63	.026	2.59	
		Natural	50.82	.089	7.23							
	Charlotte	Dried	54.35	.090	14.60	.45	2.85	.81	1.40	.022	1.96	
		Natural	48.07	.080	12.91							11.56
Cambria		Dried	57.90	.093	9.82	.24	2.64	.76	.48	.013	3.17	
		Natural	51.54	.083	8.74							10.98
Champion		Dried	61.90	.078	5.15							
		Natural	61.35	.077	5.11							.88
Cliff Shaft	Crushed Cliff Shaft	Dried	59.20	.112	6.42	.51	2.74	1.87	.82	.014	1.92	
		Natural	58.61	.111	6.37							1.00
	Lump Cliff Shaft	Dried	59.70	.103	4.90	.79	2.46	1.75	1.12	.016	2.75	
		Natural	59.40	.102	4.88							.50
Empire		Dried	40.23	.074	40.60	.08	1.02	.49	.24	.025	1.10	
		Natural	39.01	.072	39.37							3.03
Hartford	Bernhart	Dried	59.14	.074	11.98							
		Natural	50.53	.066	10.78							10.00
	Averhart	Dried	59.52	.059	8.04							
		Natural	53.52	.053	7.23							10.07
*Himrod		Dried	41.75	.054	36.20	.03	1.28	.38	.05	.005	1.50	
		Natural	40.08	.052	34.75							4.00
*Imperial		Dried	51.40	.032	11.15	.180	.64	2.98	2.12	.021	8.63	
		Natural	45.39	.267	9.85							11.70
	Jackson Bessemer	Dried	50.30	.042	24.50	.10	2.00	.35	.08	.015	1.00	
		Natural	49.29	.041	24.01							2.01

[1] Published by the Lake Superior Iron Ore Association.

* Expected analysis for 1911.

AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE FOR 1910.[1] (Concluded.)

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
	South Jackson	Dried	41.70	.086	31.50	2.60	1.51	.34	.27	.022	2.48	
		Natural	38.68	.080	29.22							7.25
	Lake	Dried	58.70	.108	6.68	.70	2.68	.65	.98	.015	3.75	
		Natural	51.07	.094	5.81							13.00
	Lake Bessemer	Dried	60.00	.048	9.73	.54	1.27	.66	.30	.011	1.45	
		Natural	51.02	.042	8.44							13.30
Lake Superior (Hard)	Abbotsford	Dried	62.13	.033	6.30							
		Natural	59.78	.032	7.98							3.78
	Beresford Lump	Dried	62.58	.110	5.40							
		Natural	61.59	.108	5.32							1.59
	Castleguard	Dried	53.01	.045	20.87							
		Natural	50.63	.043	19.94							4.48
	Castleford	Dried	53.97	.086	16.51							
		Natural	51.91	.082	15.88							3.81
	High Grade Hematite	Dried	60.40	.082	8.39							
		Natural	52.08	.070	7.23							13.78
Lake Superior (Soft)	Alford	Dried	62.89	.028	6.69							
		Natural	56.68	.025	6.03							9.87
	Bedford	Dried	55.11	.073	13.63							
		Natural	49.61	.066	12.27							9.98
Lillie		Dried	58.21	.090	9.20	.26	2.56	.78	.40	.016	3.47	
		Natural	51.23	.079	8.10							11.99
Maas		Dried	58.80	.089	8.50	.25	2.56	1.23	.27	.018	2.60	
		Natural	52.04	.079	7.52							11.50
Mary Charlotte No. 1	Mary	Dried	58.73	.013	8.35	.23	2.98	.62	.63	.026	2.59	
		Natural	50.82	.089	7.23							13.47
	Charlotte	Dried	54.35	.090	14.60	.45	2.85	.81	1.40	.022	1.96	
		Natural	48.07	.079	12.91							11.56
Mary Charlotte No. 2	Mary	Dried	58.73	.103	8.35	.23	2.98	.62	.63	.026	2.59	
		Natural	50.82	.089	7.23							13.47
	Charlotte	Dried	54.35	.090	14.60	.45	2.85	.81	1.40	.022	1.96	
		Natural	48.07	.079	12.91							11.56
*Milwaukee-Davis	Milwaukee	Dried	62.05	.105	4.32	.45	.60	1.10	.90	.08	2.10	
		Natural	55.85	.095	3.89							10.00
	Davis	Dried	61.40	.127	5.25	.45	1.19	1.10	.72	.02	2.08	
		Natural	55.26	.114	4.73							10.00
Moro		Dried	60.30	.140	8.40	.12	2.72	.58	.12	.020	.30	
		Natural	60.00	.139	8.36							.50
Negaunee	Negaunee	Dried	58.80	.089	8.50	.25	2.56	1.23	.27	.018	2.60	
		Natural	52.04	.079	7.52							11.50
	Negaunee Bessemer	Dried	59.80	.060	7.65	.24	2.69	1.12	.23	.013	2.20	
		Natural	53.22	.053	6.81							11.00
*Ogden		Dried	41.70	.045	37.10	.37	.69	.30	.13	.010	1.20	
		Natural	41.14	.044	36.60							1.34
Queen	Buffalo	Dried	60.12	.112	6.18							
		Natural	51.40	.096	5.30							14.36
	Cameo	Dried	57.24	.104	8.77							
		Natural	48.99	.089	7.51							14.41
Republic	Republic	Dried	62.82	.049	7.93	.04	1.44	.56	.61	.028	.28	
		Natural	62.20	.049	7.85							.96
	Basic	Dried	63.65	.077	5.54	.06	1.50	.56	.90	.027	.14	
		Natural	62.80	.076	5.47							1.33
	Lump	Dried	66.40	.094	2.36	.06	.95	.52	.72	.012	none	
		Natural	65.86	.093	2.34							.82
Richmond		Dried	40.90	.040	38.10	.12	.81	.35	.80	.014	1.31	
		Natural	39.66	.039	36.95							3.03
Rolling Mill		Dried	59.76	.102	8.25							
		Natural	51.60	.088	7.12							13.65
Salisbury	Clinton	Dried	60.50	.220	6.75	.30	2.30	.70	.23	.014	2.57	
		Natural	53.24	.194	5.94							12.00
	Clinton Silica	Dried	51.50	.106	19.35	.26	2.46	.30	.16	.012	2.68	
		Natural	45.06	.093	16.93							12.50
	Salisbury	Dried	59.10	.110	7.00	.60	3.00	1.20	1.20	.040	2.50	
		Natural	50.83	.095	6.02							14.00
*Star West		Dried	54.16	.037	18.42	.21	.76	1.10	.85	.002	1.12	
		Natural	53.21	.036	18.09							1.76
Washington	Washington	Dried	60.20	.137	10.43	.06	1.52	.93	.84	.021	.34	
		Natural	59.61	.136	10.33							.98
	Washington No. 2	Dried	57.12	.123	14.03	.33	1.68	.66	.62	.016	1.60	
		Natural	56.68	.122	13.92							.77
	Washington Siliceous	Dried	50.00	.100	25.00	.44	.84	.88	.10	.031	.42	
		Natural	49.50	.099	24.75							1.00

[1] Published by the Lake Superior Iron Ore Association.
* Expected analysis for 1911.

AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE GWINN DISTRICT FOR 1910.

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Austin	....	Dried	60.80	.086	8.95	.52	.71	.88	.28	.012	.95	14.00
		Natural	52.29	.074	7.70							
Princeton	Princeton	Dried	59.70	.197	8.80	.48	.95	1.60	.62	.013	1.20	14.00
		Natural	51.34	.169	7.56							
	Cambridge	Dried	60.00	.667	6.12	.74	1.07	2.15	.42	.014	1.25	14.00
		Natural	51.60	.574	5.26							
Stegmiller	....	Dried	60.34	.381	6.97	.....	.....	.....	.....	.....	.....	14.71
		Natural	51.44	.325	5.95							
Stephenson	....	Dried	60.00	.667	6.12	.74	1.07	2.15	.42	.014	1.25	14.00
		Natural	51.60	.574	5.26							

ANNUAL LAKE ERIE PRICES, FREIGHT RATES AND MINE VALUES OF MICHIGAN IRON ORES, 1855-1911.[1]

Year.	Marquette Range.									
	Rail freight.		Boat freight.		Price at Lake Erie ports.		Value of ore at the mines.			
							Shipped via Marquette.		Shipped via Escanaba.[2]	
	To Marquette.	To Escanaba.	From Marquette.	From Escanaba.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.
1855	$3 00	.....	$3 00	.....	$10 00	$10 00	$4 00	$4 00	.....	.....
1856	1 27	.....	3 00	.....	8 00	8 00	3 73	3 73	.....	.....
1857	1 27	.....	2 67	.....	8 00	8 00	4 06	4 06	.....	.....
1858	87	.....	2 09	.....	6 50	6 50	3 54	3 54	.....	.....
1859	87	.....	2 00	.....	6 00	6 00	3 13	3 13	.....	.....
1860	1 09	.....	2 00	.....	5 25	5 50	2 16	2 41	.....	.....
1861	1 09	.....	2 21	.....	5 25	5 00	1 95	1 70	.....	.....
1862	1 09	.....	2 89	.....	5 25	5 37	1 27	1 39	.....	.....
1863	1 09	.....	3 19	.....	7 50	7 50	3 22	3 22	.....	.....
1864	1 09	.....	3 37	.....	8 50	8 50	4 04	4 04	.....	.....
1865	1 10	.....	3 23	.....	7 50	7 50	3 17	3 17	.....	.....
1866	1 10	$1 55	4 17	$3 77	9 50 14 00	..... 4 23	4 23 8 73	..... 4 18	$4 23 8 68	.....
1867	1 10	1 80	2 98	3 28	10 50	8 00 11 50	..... 6 42	3 92 7 42	..... 5 42	$2 92 6 42
1868	1 10	1 80	3 11	2 44	8 25	8 25	4 04	4 04	4 20	4 20
1869	1 10	1 85	3 21	2 43	8 25	9 50	3 94	5 19	3 97	5 22
1870	1 10	1 85	3 06	2 40	8 50	8 50 9 50	..... 4 34	4 34 5 34	..... 4 25	4 25 5 25
1871	95	1 70	2 83	2 07	8 00	8 00	4 22	4 22	4 23	4 23
1872	84	1 70	3 59	2 50	9 00	7 50	4 57	3 07	4 80	3 30
1873	84	2 00	3 44	2 74	12 00	9 00	7 72	4 72	7 26	4 26
1874	84	2 00	3 84	.....	9 00	7 00	4 32	2 32	.....	.....
1875	65	1 25	2 87	.....	7 00	5 50	3 48	1 98	.....	.....
1876	55	1 15	2 54	.....	6 75	4 50	3 66	1 41	.....	.....
1877	55	1 15	1 40	.....	6 50	4 25	4 55	2 30	.....	.....
1878	55	1 15	1 26	85	5 50	4 25	3 69	2 44	3 50	2 25
1879	55	1 15	1 61	1 07	6 25	4 75	4 09	2 59	4 03	2 53
1880	55	1 25	2 50	1 77	9 25	8 00	6 20	4 95	6 23	4 98
1881	55	1 25	2 25	1 55	9 00	7 00	6 20	4 20	6 20	4 20
1882	55	1 25	1 50	1 22	9 00	6 25	6 95	4 20	6 53	3 78
1883	55	1 10	1 30	1 11	6 25	5 00	4 40	3 15	4 04	2 79
1884	40	80	1 21	98	5 76	4 50	4 15	2 89	3 98	2 72
1885	45	80	1 01	84	5 50	4 25	4 04	2 79	3 86	2 61
1886	55	80	1 35	1 16	5 50	4 75	3 60	2 85	3 54	2 79
1887	55	80	1 75	1 49	7 25	5 25	4 95	2 95	4 96	2 96
1888	45	70	1 22	97	5 50	4 75	3 83	3 08	3 83	3 08
1889	45	70	1 14	1 00	5 50	4 50	3 91	2 91	3 80	2 80
1890	45	70	1 16	99	6 75	5 75	5 14	4 14	5 06	4 06
1891	45	70	96	74	6 00	4 74	4 59	3 34	4 56	3 31
1892	40	65	1 06	87	5 50	4 85	4 04	3 39	3 98	3 33
1893	40	65	85	70	4 25	3 00 3 50	..... 3 00	1 75 2 25	..... 2 90	1 65 2 15
1894	32	.....	70	53	2 75	2 15	1 73	1 13	.....	.....

[1] Compiled from various sources.

ANNUAL LAKE ERIE PRICES, FREIGHT RATES AND MINE VALUES OF MICHIGAN IRON ORES, 1855-1911.[1]

(Concluded.)

Year.	Marquette Range. Rail freight. To Marquette.	Rail freight. To Escanaba.	Boat freight. From Marquette.	Boat freight. From Escanaba.	Price at Lake Erie ports. Bessemer.	Price at Lake Erie ports. Non-Bessemer.	Value of ore at the mines. Shipped via Marquette. Bessemer.	Shipped via Marquette. Non-Bessemer.	Shipped via Escanaba. Bessemer.	Shipped via Escanaba. Non-Bessemer.
1895	$0 32	$0 52	$0 83	$0 64	$2 75	$2 15	$1 60	$1 00	$1 59	$0 99
					3 50	2 30	2 35	1 15	2 34	1 14
1896	32	52	80	61	4 00	2 45	.....	1 33	.....	1 32
						2 85	2 88	1 73	2 78	1 72
1897	32	52	60	45	2 65	2 00	.....	1 08	.....	1 03
						2 60	1 73	1 68	1 68	1 63
1898	32	40	60	48	3 10	2 35	2 18	1 43	2 22	1 47
					3 35	2 45	2 43	1 53	2 47	1 57
1899	25	40	84	72	3 21	2 50	2 12	.....	2 09	.....
					3 50	....	2 41	1 41	2 38	1 38
1900	25	40	94	85	5 93	....	4 74	.....	4 68	.....
					6 48	5 00	5 29	3 81	5 23	3 75
1901	25	40	74	62	4 66	3 65	3 67	2 66	3 64	2 63
					4 92	3 85	3 93	2 86	3 90	2 83
1902	25	40	68	59	4 65	3 80	3 72	2 87	3 66	2 81
					5 00	4 00	4 07	3 07	4 01	3 01
1903	25	40	73	63	4 85	4 00	3 87	3 02	3 82	2 97
					5 15	4 25	4 17	3 27	4 12	3 22
1904	25	40	61	54	3 60	3 10	2 74	2 24	2 66	2 16
1905	32	40	70	60	3 85	3 35	2 99	2 49	2 91	2 41
					3 75	3 20	2 73	2 18	2 75	2 20
1906	32	40	70	60	4 25	3 70	3 23	2 68	3 25	2 70
1907	32	40	70	60	5 00	4 20	3 98	3 18	4 00	3 20
1908	32	40	60	50	4 50	3 70	3 58	2 78	3 60	2 80
1909	32	40	60	50	4 50	3 70	3 58	2 78	3 60	2 80
1910	32	40	65	55	5 00	4 20	4 03	3 23	4 05	3 25
1911	......	......	55	45	4 50	3 70	......	......	......	......

[1] Compiled from various sources.

ANNUAL LAKE ERIE PRICES, FREIGHT RATES AND MINE VALUES OF MICHIGAN IRON ORES, 1855-1911.[1]

(Concluded.)

Year.	Menominee Range. Rail freight. To Escanaba.	Boat freight. From Escanaba.	Price of ore at Lake Erie ports. Bessemer.	Price of ore at Lake Erie ports. Non-Bessemer.	Value of ore at the mines. Bessemer.	Value of ore at the mines. Non-Bessemer.	Gogebic Range. Rail freight. To Ashland.	Boat freight. From Ashland.	Price of ore at Lake Erie ports. Bessemer.	Price of ore at Lake Erie ports. Non-Bessemer.	Value of ore at the mines. Bessemer.	Value of ore at the mines. Non-Bessemer.
1883	......	......	$6 00	$4 75	......	......	......	......	......	......	......	......
1884	......	......	5 25	4 50	......	......	......	......	......	......	......	......
1885	......	......	4 75	4 00	......	......	......	......	......	......	......	......
1886	......	......	5 25	4 50	......	......	......	......	......	......	......	......
1887	$0 85	$1 49	6 00	5 00	$3 66	$2 66	$0 80	$2 11	$6 00	$5 00	$3 09	$2 09
1888	75	97	4 75	4 00	3 03	2 28	70	1 34	4 75	4 00	2 71	1 96
1889	75	1 00	4 50	4 50	2 75	2 75	70	1 29	4 50	4 50	2 51	2 51
1890	......	99	5 50	5 25	4 51	4 26	70	1 26	5 50	5 25	3 54	3 29
1891	70	74	4 50	4 25	3 06	2 81	65	1 05	4 50	4 25	2 80	2 55
1892	70	87	4 50	3 65	2 93	2 08	65	1 20	4 50	3 65	2 65	1 80
1893	70	70	3 85	3 20	2 41	1 76	65	88	3 85	3 20	2 32	1 67
							52	.....	.....	.....	1 44	1 19
1894	70	53	2 75	2 50	1 52	1 27	65	79	2 75	2 50	1 31	1 06
1895	52	64	2 90	2 25	1 74	1 09	52	96	2 90	2 25	1 42	77
1896	52	61	4 00	2 70	2 87	1 57	52	91	4 00	2 70	2 57	1 27
							45	.....	.....	.....	1 52	1 45
1897	52	45	2 60	2 15	1 63	1 18	52	63	2 60	2 15	1 07	1 00
							40	.....	.....	.....	84	1 69
1898	45	48	2 75	1 85	1 82	92	45	61	2 75	1 85	1 74	79
1899	40	72	3 00	2 15	1 88	1 03	40	95	3 00	2 15	1 65	80
1900	40	85	5 50	4 25	4 25	3 00	40	1 05	5 50	4 25	4 05	2 80
1901	40	62	4 25	3 00	3 23	1 98	40	84	4 25	3 00	3 01	1 76
1902	40	59	4 25	3 25	3 30	2 26	40	76	4 25	3 25	3 09	2 09
1903	40	63	4 50	3 60	3 47	2 57	40	83	4 50	3 60	3 27	2 37
1904	40	54	3 25	2 75	2 31	1 81	40	70	3 25	2 75	2 15	1 65
1905	40	60	3 75	3 20	2 75	2 20	40	76	3 75	3 20	2 59	2 04
1906	40	60	4 25	3 70	3 25	2 70	40	75	4 25	3 70	3 10	2 55
1907	40	60	5 00	4 20	4 00	3 20	40	75	5 00	4 20	3 85	3 05
1908	40	50	5 00	4 20	4 10	3 30	40	65	5 00	4 20	3 95	3 15
1909	40	50	4 50	3 70	3 60	2 80	40	65	4 50	3 70	3 45	2 65
1910	40	55	5 00	4 20	4 05	3 25	40	70	5 00	4 20	3 90	3 10
1911	......	45	4 50	3 70	......	......	......	60	4 50	3 70	......	......

[1]Compiled from various sources.

LIST OF THE ACTIVE IRON MINES OF MICHIGAN, 1910, WITH LOCATION, OWNERSHIP, SALES AGENTS, ETC.

Name of mine.	Location				First shipment.	No. of men employed.	Depth 1910.	Operators.	Sales agents.
	County.	Section.	Twp.	Range.					
MARQUETTE RANGE:									
American	Marquette	32	48	28	1880	312	850	American Boston Mining Co	M. A. Hanna & Co., Cleveland, Ohio.
Angeline	Marquette	15	47	27	1864	411	515	Pittsburg & Lake Angeline Iron Co.	
Bessie	Marquette	35	46	29	1891		200	John M. Longyear	John M. Longyear, Marquette, Michigan.
Breitung Hematite No. 1	Marquette	8	47	26	1903	......	367	......	E. N. Breitung & Co., Cleveland, Ohio.
Breitung Hematite No. 2	Marquette	8	47	26	......	......	368	......	E. N. Breitung & Co., Cleveland, Ohio.
Cambria	Marquette	35	48	27	1875	131	883	Republic Iron & Steel Co.	M. A. Hanna & Co., Cleveland, Ohio.
Champion	Marquette	31, 32	48	29	1867	103	2,292	Oliver Iron Mining Co.	
Cliff Shaft	Marquette	9, 10	47	27	1887	290	736	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Empire	Marquette	19	47	26	1907	....	200	Empire Iron Co	Oglebay, Norton & Co., Cleveland, Ohio.
Hartford	Marquette	36	48	27	1889	....	1,075	Republic Iron & Steel Co.	M. A. Hanna & Co., Cleveland, Ohio.
Imperial	Baraga	25	48	31	1890	80	186	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Jackson	Marquette	1	47	27	1846	48	Open pit	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Lake	Marquette	10	47	27	1892	545	555	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Lake Superior (Hard Ore)	Marquette	9, 10	47	27	1858	385	1,070	Oliver Iron Mining Co.	
Lake Superior (Soft Ore)	Marquette	10	47	27	1858	385	1,102	Oliver Iron Mining Co.	
Lillie	Marquette	35	48	27	1875	55	1,000	Republic Iron & Steel Co.	M. A. Hanna & Co., Cleveland, Ohio.
Lucy	Marquette	6, 7	47	26	1878	18	281	Cleveland Cliffs Iron Co.	
Mass	Marquette	31	48	26	1907	174	1,100	Cleveland Cliffs Iron Co.	
Maitland	Marquette	30	47	26	......	......	300	Volunteer Ore Co.	
Mary Charlotte No. 1	Marquette	8	47	26	1903	} 453	365	......	E. N. Breitung & Co., Cleveland, Ohio.
Mary Charlotte No. 2	Marquette	8	47	26	......		470	......	E. N. Breitung & Co., Cleveland, Ohio.
Milwaukee-Davis	Marquette	7	47	26	1879	......	373	......	E. N. Breitung & Co., Cleveland, Ohio.
Moro	Marquette	10	47	27	1881	......	812	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Negaunee	Marquette	5, 6	47	26	1887	346	686	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Ogden	Marquette	13	47	27	1892	......	Open pit	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Queen	Marquette	5	47	26	1888	336	923	Oliver Iron Mining Co.	
Republic	Marquette	7	46	29	1872	437	1,950	Republic Iron Co.	M. A. Hanna & Co., Cleveland, Ohio.
Richmond	Marquette	28	47	26	1896	82	Open pit	Richmond Iron Co.	M. A. Hanna & Co., Cleveland, Ohio.
Rolling Mill	Marquette	City of Negaunee		......	1872	120	698	Jones & Laughlin Ore Co.	
Salisbury	Marquette	15	47	27	1872	167	900	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Volunteer	Marquette	30	47	26	1871	51	428	Volunteer Ore Co.	
Washington	Marquette	11	47	29	1865	146	572	Washington Iron Co.	E. N. Breitung & Co., Cleveland, Ohio.
SWANZY DISTRICT:									
Austin	Marquette	20	45	25	1907	201	318	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Princeton	Marquette	18, 20	45	25	1872	191	383	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Stegmiller	Marquette	17	45	25	1909	44	346	Oliver Iron Mining Co.	
Stephenson	Marquette	20	45	25	1907	40	413	Cleveland Cliffs Iron Co.	
MENOMINEE RANGE:									
Antoine	Dickinson	17, 20	40	30	1895	......	135	......	Oglebay, Norton & Co., Cleveland, Ohio.
Aragon	Dickinson	8, 9	39	29	1889	......	1,083	Oliver Iron Mining Co.	
Chapin	Dickinson	25, 30	40	31, 30	1880	429	1,522	Oliver Iron Mining Co.	
Cyclops & Norway	Dickinson	5	39	29	1878	727	355	Penn Iron Mining Co.	
East Vulcan	Dickinson	10, 11	39	29	1877	......	1,400	Penn Iron Mining Co.	
Loretto	Dickinson	7	39	28	1893	161	800	Loretto Iron Co.	M. A. Hanna & Co., Cleveland, Ohio.
Millie (Hewitt)	Dickinson	31	40	34	1881	63	600	Dessau Mining Co.	M. A. Hanna & Co., Cleveland, Ohio.
Munro	Dickinson	6	39	29	1903	......	141	Munro Mining Co.	Rogers, Brown Iron Co., Buffalo, N. Y.
Pewabic	Dickinson	32	40	30	1890	482	941	Pewabic Co.	Pickands, Mather & Co., Cleveland, Ohio.
Quinnesec	Dickinson	34	40	30	1878	......	......	Corrigan, McKinney Co.	Corrigan, McKinney & Co., Cleveland, Ohio.
Vivian	Dickinson	34	40	30	1902	32	310	Verona Mining Co.	Pickands, Mather & Co., Cleveland, Ohio.
West Vulcan, Curry & Brier Hill	Dickinson	9, 10	39	29	1879	807[3]	1,500	Penn Iron Mining Co.	
Clifford and Traders	Dickinson	20	40	30	......	......	......	Antoine Ore Company.	
METROPOLITAN TROUGH:									
Groveland	Dickinson	31	42	29	1891	45	275	Groveland Mining Co.	Lake Erie Ore Co., Cleveland, Ohio.
CALUMET TROUGH:									
Calumet	Dickinson	8	41	23	1882	......	215	Verona Mining Co.	Pickands, Mather & Co., Cleveland, Ohio.

[3] Includes Cyclops, Norway and East Vulcan.

LIST OF THE ACTIVE IRON MINES OF MICHIGAN, 1910, WITH LOCATION, OWNERSHIP, SALES AGENTS, ETC.

Name of mine.	Location.				First shipment.	No. of men employed.	Depth 1910.	Operators.	Sales agents.
	County.	Section.	Twp.	Range.					
CRYSTAL FALLS DISTRICT:									
Tobin	Iron	30	43	32	1901	......	....	Corrigan, McKinney Co	Corrigan, McKinney Co., Cleveland, Ohio.
Armenia	Iron	23	43	32	1889	84	....	Corrigan, McKinney Co	Corrigan, McKinney Co., Cleveland, Ohio.
Bristol	Iron	19	43	32	1892	206	900	Bristol Mining Co.	Oglebay, Norton & Co., Cleveland, Ohio.
Dunn	Iron	1	42	33	1887	135	135	Corrigan, McKinney Co	Corrigan, McKinney Co , Cleveland, Ohio.
Genesee	Iron	29,30,31	43	32	1902	......	....	Corrigan, McKinney Co	Corrigan, McKinney Co., Cleveland, Ohio.
Great Western	Iron	21	43	32	1882	283	....	Corrigan, McKinney Co	Corrigan, McKinney Co., Cleveland, Ohio.
Hemlock	Iron	4	44	33	1891	143	935	Hemlock River Mining Co	Pickands, Mather & Co., Cleveland, Ohio.
Hollister	Iron	13	43	33	1890	72	500	Hollister Mining Co.	M. A. Hanna & Co., Cleveland, Ohio.
Mansfield	Iron	17, 20	43	31	1890	95	1,189	Oliver Iron Mining Co.	
McDonald	Iron	23	43	32	1909	......	240	McDonald Mining Co.	The Lake Erie Ore Co., Cleveland, Ohio.
Michigan	Iron	9	44	33	1893	18	541	Oliver Iron Mining Co.	
IRON RIVER DISTRICT:									
Tully	Iron	36	49	35	1910	88[1]	....	Corrigan, McKinney Co	Corrigan, McKinney Co., Cleveland, Ohio.
Baker	Iron	31	43	34	1909	......	....	Corrigan, McKinney Co	Corrigan, McKinney Co., Cleveland, Ohio.
Berkshire	Iron	6	42	34	1908	51	365	Brule Mining Co.	Oglebay, Norton & Co., Cleveland, Ohio
Caspian	Iron	1	42	35	1903	209	292	Verona Mining Co	Pickands, Mather & Co., Cleveland, Ohio.
Chatham	Iron	35	43	35	1907	88	500	Brule Mining Co.	Oglebay, Norton & Co., Cleveland, Ohio.
Davidson No. 1	Iron	23	43	35	......	76 (Davidson No. 1 and No. 2, bracketed)	450	Davidson Ore Mining Co.	
Davidson No. 2	Iron	14	43	35	......		150	Davidson Ore Mining Co.	
Fogarty	Iron	1	42	35	1907	222[2]	255	Verona Mining Co	Pickands, Mather & Co., Cleveland, Ohio.
Hiawatha	Iron	35	43	35	1893	......	665	Munro Mining Co.	The Rogers, Brown Iron Ore Co., Buffalo, N. Y.
Wauseca	Iron	23	43	35	1910	......	301	Mineral Mining Co.	Pickands, Mather & Co., Cleveland, Ohio.
Nanaimo	Iron	26	43	35	1886	......	362	Mineral Mining Co.	Pickands, Mather & Co., Cleveland, Ohio.
Osana	Iron	23	43	35	1907	142	428	Mineral Mining Co.	Pickands, Mather & Co., Cleveland, Ohio.
Riverton	Iron	1, 35, 36	42, 43	35	1898	......	696	Oliver Iron Mining Co.	
Tully	Iron	36	43	35	1910	88[1]	....	Corrigan, McKinney Co	Corrigan, McKinney Co., Cleveland, Ohio.
Youngs	Iron	12	42	35	1905	165	419	Huron Iron Co	The Lake Erie Ore Co., Cleveland, Ohio.
Chicagon	Iron	26	43	34	1911	......	500	Munro Mining Co.	
Zimmerman	Iron	7	42	34	1908	40	600	Spring Valley Iron Co	
Baltic	Iron	7	42	34	1901	222[2]	600		
GOGEBIC RANGE:									
Anvil	Gogebic	14	47	46	1887	......	1,700	Newport Mining Co.	M. A. Hanna & Co., Cleveland, Ohio.
Asteroid	Gogebic	13	47	46	1906	......	884	Castile Mining Co.	Oglebay, Norton & Co., Cleveland, Ohio.
Ashland	Gogebic	22	47	47	1885	267	1,324	Cleveland Cliffs Iron Co.	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Brotherton	Gogebic	9	47	45	1886	175	1,075	Brotherton Iron Mining Co	Pickands, Mather & Co., Cleveland, Ohio.
Castile	Gogebic	10	47	45	1906	163	1,111	Castle Mining Co	Oglebay, Norton & Co., Cleveland, Ohio.
Colby	Gogebic	16	47	46	1884	70	....	Corrigan, McKinney Co	Corrigan, McKinney Co., Cleveland, Ohio.
Eureka	Gogebic	13	47	46	1890	......	1,173	Castile Mining Co.	Oglebay, Norton & Co., Cleveland, Ohio.
Ironton	Gogebic	17	47	46	1886	573	....	Corrigan, McKinney Co.,	Corrigan, McKinney Co., Cleveland, Ohio.
Mikado	Gogebic	18	47	45	1895	157	938	Verona Mining Co	Pickands, Mather & Co., Cleveland, Ohio.
Newport	Gogebic	24	47	47	1886	1,277	2,200	Newport Mining Co.	M. A. Hanna & Co., Cleveland, Ohio.
Norrie-Aurora	Gogebic	22, 23	47	47	1884	1,245	1,670	Oliver Iron Mining Co.	
Puritan	Gogebic	17	47	46	1886	79	1,264	Oliver Iron Mining Co.	
Sunday Lake	Gogebic	10	47	45	1885	153	1,020	Sunday Lake Iron Co	Pickands, Mather & Co., Cleveland, Ohio.
Tilden	Gogebic	15	47	46	1891	298	1,406	Oliver Iron Mining Co.	
Yale	Gogebic	16	47	46	1901	195	1,780	Lake Superior Iron & Chemical Co.	Oglebay, Norton & Co., Cleveland, Ohio.

[1] Baker and Tully. [2] Baltic and Fogarty.

PIG IRON INDUSTRY IN MICHIGAN.

BY ALBERT E. WHITE.[1]

CONTENTS.

CHAPTER I.

INTRODUCTION. PRODUCTION.

Because of the vast iron ore wealth of Michigan, there is no question before the people of the State today of greater interest than that pertaining to the use of these selfsame iron ores. Hitherto it has been true that the majority of ores mined in the State have been shipped to points outside of the State's domains for smelting. This tendency has been due to several causes. Important among these are the facts that there are points such as those existing in Chicago, Cleveland, Buffalo, Pittsburg, etc., which are nearer the points of actual steel consumption than any localities found in

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Michigan. It is of course true that it is cheaper to ship a raw material such as ore than it is to ship a finished product such as steel. Combined with this reason there is the further fact that the localities mentioned above, particularly Pittsburg, are favored by being near the coal fields, and coal is a product of prime importance in the production of iron or steel. This feature may be noted by the fact that in the production of one ton of coke pig iron—and over 90% of our pig iron made today is smelted with coke—approximately 2,200 pounds of coke are required. Converting this figure into coal terms it is noted that approximately 3,400 pounds of coal are required for one ton of pig iron, and for the production of steel from the raw ore from 4,000 to 5,000 pounds of coal are required for a ton of steel produced. For these reasons, the one because of location and the other because of fuel supply, and because Michigan lacks both of these essentials, it will be true that Michigan will never be a large pig iron producing center. This fact holds particularly true with reference to the production of coke pig iron in Michigan, and it will probably be many years before any further coke blast furnaces will be built other than those which are already located in Detroit at the plant of the Detroit Iron and Steel Company and the plant of the Detroit Furnace Company.

The standing of Michigan as a charcoal pig iron producing center is an entirely different question, and assumes an entirely different aspect for at the present writing she makes more charcoal pig iron than all of the other states combined. This condition is due to the fact that she has her rich ore mines and she likewise has, especially in the Northern Peninsula, large tracts of woodland which are capable of producing large quantities of charcoal for many years to come. It is true, of course, that the forests in Michigan are gradually being denuded, but it is estimated that there is enough wood in the State at the present time to keep the present number of blast furnaces in operation at their present rate for a period of fifty years. By proper conservation and growth of new trees it could very likely be true that Michigan could produce her present yearly output of charcoal pig iron for almost an indefinite period.

A conception of the importance of this industry should be gleaned from an examination of the following table which shows the yearly production of pig iron in the United States from 1854 to the present time and the part Michigan has played in this production since 1872.

PIG IRON PRODUCTION.

Year.	Michigan production.	U. S. Production.			Total
		Charcoal.	Anthracite.	Bituminous.	
1854		342,298	339,435	54,485	736,218
1855		339,922	381,866	62,390	784,178
1856		370,470	443,113	69,554	883,137
1857		330,321	390,385	77,451	798,157
1858		285,313	361,430	58,351	705,094
1859		284,041	471,745	84,841	840,627
1860		278,331	519,211	122,228	919,770
1861		195,278	409,229	127,037	731,544
1862		186,660	470,315	130,687	787,662
1863		212,005	577,638	157,961	947,604
1864		241,853	684,018	210,125	1,135,996
1865		262,342	479,558	189,682	931,582
1866		332,580	749,367	268,396	1,350,343
1867		344,341	798,638	318,647	1,461,626
1868		370,000	893,000	340,000	1,603,000
1869		392,150	971,150	553,341	1,916,641
1870		365,000	930,000	570,000	1,865,000
1871		385,000	956,608	570,000	1,911,608
1872	86,840	500,587	1,369,812	984,159	2,854,558
1873	113,975	577,620	1,312,754	977.904	2,868,278
1874	128,965	576,557	1,202,144	910,712	2,689,413
1875	101,805	410,990	908,046	947,545	2,266,581
1876	82,477	308,649	794,578	990,009	2,093,236
1877	75,216	317,843	934,797	1,061,945	2,314,585
1878	70,853	293,399	1,092,870	1,191,092	2,577,361
1879	101,539	358,873	1,273,024	1,438,978	3,070,875
1880	154,424	537,558	1,807,651	1,950,025	4,295,414
1881	187,043	638,838	1,734,462	2,268,264	4,641,564
1882	210,195	697,906	2,042,138	2,438,078	5,178,122
1883	173,185	571,726	1,885,596	2,689,650	5,146,972
1884	172,834	458,418	1,586,453	2,544,742	4,589,613
1885	143,121	399,844	1,454,390	2,675,635	4,529,869
1886	190,734	459,557	2,099,597	3,806,174	6,365,328
1887	190,663	529,457	1,901,256	2,957,232	6,387,945
1888	190,403	598,789	1,925,729	4,743,989	7,268,507
1889	191,395	644,300	1,920,354	5,952,414	8,517,068
1890	230,769	703,522	2,448,781	7,154,725	10,307,028
1891	213,145	576,964	1,866,108	5,836,798	8,279,870
1892	184,421	537,621	1,797,113	6,822,266	9,157,000
1893	117,538	386,789	1,347,529	5,390,184	7,124,502
1894	95,171	222,422	914,742	5,520,224	6,657,388
1895	91,222	225,341	1,270,899	7,950,068	9,446,308
1896	149,511	310,244	1,146,412	7,166,471	8,623,127
1897	132,578	255,211	932,777	8,464,692	9,652,680
1898	147,640	296,750	1,203,273	10,273,911	11,773,934
1899	134,443	284,766	1,599,552	11,736,385	13,620,703
1900	163,712	299,124	1,841,857	12,253,818	13,789,242
1901	170,762	390,147	1,712,527	13,782,386	15,878,354
1902	155,213	378,504	1,115,247	16,315,891	17,821,307
1903	244,709	504,757	1,911,347	15,592,221	18,009,252
1904	233,225	337,529	1,228,140	14,931,364	16,497,633
1905	288,704	352,928	*1,300,000	*21,339,452	22,992,380
1906	369,456	433,007	1,305,094	23,313,498	25,307,191
1907	436,507	437,397	1,371,554	23,972,410	25,781,361
1908	348,096	249,146	355,009	15,331,865	15,936,018
1909	964,289	376,003	698,431	24,721,037	25,795,471
1910	1,250,103	394,377	649,082	26,255,086	27,298,545
1911	542,193	160,847	149,227	11,355,722	11,665,796

*Estimated.

Note:—These figures may not altogether tally because great difficulty was encountred in preparing the table; for at best the figures had to be obtained from many and various sources.

Michigan's production from 1906 includes the production in Indiana also. To 1906 the production is altogether charcoal. Michigan's production for 1903, 1904 and 1905 is not quite complete as it does not have the tonnage of coke pig iron made in the State during those years.

1911's figures are for the half year from January 1st to July 1st.

The figures up to 1891 are in net tons. Beginning with 1891 the figures are in gross tons.

HISTORY AND DEVELOPMENT OF THE INDUSTRY.

No notice of Michigan as a pig iron producing center was taken to any marked extent until about 1840. At that time it was reported that there were fifteen blast furnaces in the State. Many of these were doubtless forges and as such could not be credited as being true blast furnaces. They were all in the southern part of the State. From 1840 to 1850 Michigan as an iron center suffered a decline, but from 1850 to 1860 considerable progress took place in the industry. This progress consisted in the building of three new furnaces for the purpose of smelting the bog ores found in the southern part of the State and likewise in developments that took place in the Northern Peninsula. The first pig iron made in the Lake Superior region was in 1858 by Stephen R. Gay who converted a forge into a miniature blast furnace. The first regular furnace erected in this region, however, was that built by the Pioneer Iron Company in the present city of Negaunee, convenient to the well known Jackson mine. This company, which is a subsidiary of the Cleveland Cliffs Iron Company, is still in active operation, and it has been manufacturing pig iron for a longer period than any corporation doing like work within the bounds of the State. While such progress as just noted was being made in the Northern Peninsula, slight development was made in the southern portion of the State, particularly near Detroit. In that region the Eureka furnace was built in 1855 by the Eureka Iron Company with Captain E. B. Ward as President; and a furnace at Detroit, known as the Detroit Furnace, was built in 1856 by the Lake Superior Iron Manufacturing Company, with George B. Russell as President. This latter furnace, if the writer is not mistaken, is the one at present owned by the Detroit Furnace Company, and up to the past few months has been in active

operation, although for the past few years it has been using coke in place of charcoal as its metallurgical fuel. The Eureka Furnace has been one of the best known furnaces in the State and in its day has been one of the most successful of blast furnaces. The difficulty of getting ore to the furnace and the great difficulty it encountered, because of its location, in getting fuel at a reasonable cost, are the reasons why, after a long and successful operation, the furnace went out of blast.

From this time on, a minute study of the history of the pig iron industry in Michigan would, in reality, prove to be a long and probably tedious presentation of facts. Many furnaces have been built and after a short operation have either been sold to other parties, dismantled and taken elsewhere, or else completely shut down. (There has probably been less consolidation among the makers of charcoal pig iron than in any other branch of the iron and steel business. The writer knows of no definite attempt to unite the charcoal furnaces together under one strong head until the formation of the Lake Superior Iron and Chemical Company in 1910.) Such fluctuations and variations have largely been due, probably, to the lack of a sufficient supply of charcoal at any one place for a long period. It has proved more wise to either dismantle a plant or else move it to a fresh charcoal center when the supply of charcoal disappeared from the old location, than to bring charcoal to the plant from long distances. In other words, the policy has been to bring the furnace to the charcoal rather than the charcoal to the furnace.

Because of the above reasons, pig iron production in Michigan from 1870 to 1880 and from 1880 to 1890 sustained no great improvement. As regards quantity it is true that the State sent forth nearly as much pig iron as it ever had; in fact, for the most part, the quantity produced slightly increased although the percentage of increase was no greater than the percentage of increase throughout the country. For example, this State in 1880 ranked fourth as a pig iron producing center; in 1890 it had dropped to 8th place; and in 1900 it was still 8th; while in 1910 it was ranked as the 7th State, due largely to the output of the Detroit Iron and Steel Company's two coke furnaces at Detroit. It was from 1890 to 1900 that more changes of management took place than in any other period. The early part of the ten years was a period of almost continual depression, and pig iron manufacturers in Michigan suffered more financial embarrassment than they have in any of the other periods.

The last ten years have seen sort of a revolution regarding the manufacture of pig iron from charcoal. In the early days wood was cut and charcoal made from it without in any way considering the by-product values found in wood, such a wood alcohol, calcium acetate, etc. It had largely been a question of cutting wood, carbonizing it, and then smelting iron ore with it as a quick and efficient means of clearing ground and at the same time getting financial returns. In many cases the investment idea was emphasized more than the thought of clearing the ground. Such a condition encouraged men to go into the proposition to just as light an extent as possible, without giving any concern as to the future of the business. This attitude, of necessity, led to poor equipment, and an absence of all permanency. Because of these facts pig iron could be made with a high market but it could not be made at a profit with a low market.

The poor logic of this attitude was after a time realized and the companies that are in business today are doing all in their power to put the industry on a permanent footing. By means of charcoal and retort by-product kilns they are endeavoring to recover from the wood all the values possible. They are cutting the wood and developing new growths with a proper attitude toward conservation and they are equipping their furnaces with such mechanical appliances as will tend to materially reduce costs.

Up to 1903 the entire amount of pig iron made in Michigan was smelted with charcoal. For that reason everything which has been said in regard to the history of the industry in the preceding statements has related entirely to charcoal plants. In 1902 the Detroit Iron and Steel Company had its formation and in 1903 it put in blast a large merchant coke pig iron furnace in Detroit. This plant has been operated continuously since that time, with the addition in 1910 of another merchant coke furnace. Likewise in 1906 the Detroit Furnace changed hands, and since that time it has been producing coke pig iron.

With this brief resume we are taken down practically to the present writing. A tabulated list of the furnaces at present in operation or capable of being operated is presented, and a somewhat detailed statement with regard to each plant is also added.

BLAST FURNACES IN MICHIGAN.

Name of furnace.	Name of company.	Location of furnace.	Activity.	Type of fuel.	Activity of furnace.
Antrim	Antrim Iron Company	Antrim	In blast	Charcoal	115 tons
Cadillac	Mitchell-Diggins Iron Co.	Cadillac	In blast	Charcoal	100 tons
Carp	Pioneer Iron Company	Near Marquette	Idle	Charcoal	50 tons
Chocolay	Lake Superior Iron & Chemical Co.	Harvey	Idle	Charcoal	70 tons
Detroit	Detroit Furnace Company	Detroit	Idle	Coke	75 tons
East Jordan	East Jordan Furnace Company	East Jordan	In blast	Charcoal	80 tons
Elk Rapids	Lake Superior Iron & Chemical Co.	Elk Rapids	Idle	Charcoal	110 tons
Gladstone	Pioneer Iron Company	Gladstone	In blast	Charcoal	
Manistique	Lake Superior Iron & Chemical Co.	Manistique	Idle	Charcoal	110 tons
Marquette	Pioneer Iron Company	Marquette	In blast	Charcoal	120 tons
Newberry	Lake Superior Iron & Chemical Co.	Newberry	Idle	Charcoal	80 tons
Pine Lake	Lake Superior Iron & Chemical Co.	Boyne City	In blast	Charcoal	110 tons
Spring Lake	Spring Lake Iron Company	Fruitport	Idle	Charcoal	75 tons
Stevenson	Stevenson Charcoal Iron Co.	Wells	Building	Charcoal	60 tons
Zug Island A	Detroit Iron & Steel Company	Detroit	In blast	Coke	300 tons
Zug Island B	Detroit Iron & Steel Company	Detroit	In blast	Coke	325 tons

DETAILS OF BLAST FURNACES IN MICHIGAN.

Name of furnace.	Lines of furnace.					Twyeres.		Stoves.			
	Heighth.	Hearth Depth.	Bosh Diam.	Hearth Diam.	Throat Diam.	No.	Size.	No.	Size. Heighth.	Size. Diam.	Kind.
Antrim	60′	6′	12′	6′	7′	8	4″	2	....	....	Durham pipe.
Cadillac	65′	6′	11′ 4″	7′ 8″	7′ 6″	5	4″	3	60′	16′	Kennedy Brick.
Carp	58′	....	10′	....	....	....	....	....	....	....	Durham Pipe.
Chocolay	40′	....	8′	....	....	....	....	2	....	....	Durham Pipe.
Detroit	62′	7′ 8″	12′ 6″	7′ 6″	7′ 4″	7	3½″	3	....	....	Durham Pipe.
East Jordan	60′	6′ 6″	10′	6′	6′	5	4½″	2	60′	16′	Three-pass Brick.
Elk Rapids	64′	6′ 3½″	12′ 6″	7′ 6″	7′	....	....	2	....	....	Durham Pipe.
Gladstone	60′	....	12′	....	....	5	5″	3	70′	16′	Roberts-Cowper Brick.
Manistique	59′ 6″	5′ 4″	12′ 6″	7′	7′ 6″	....	....	2	....	....	Durham Pipe.
Marquette	70′	....	13′	....	....	....	....	3	....	....	Roberts-Cowper Brick.
Newberry	60′	6′	12′	7′ 6″	7′ 6″	4	4″	2	....	....	Durham Pipe.
Pine Lake	62′ 9″	6′ 8″	12′	7′ 2″	6′ 6″	....	....	2	....	....	Two Pass Brick.
Spring Lake	50′	....	11′	....	....	....	....	2	....	....	Durham Pipe.
Stevenson	60′	....	10′	....	....	....	....	2	....	....	Two Pass Brick.
Zug Island A	78′	6′	18′ 8″	13′	12′ 6″	10	5″	4	83′	20′	Garrett-Cromwell Brick.
Zug Island B	80′	7′	18′ 6″	12′ 6″	12′ 6″	12	5″	4	85′	12′	Nelson-McKee Brick.

CHAPTER II.

DETAILS REGARDING THE BLAST FURNACES IN MICHIGAN.

Because of the great diversity between charcoal pig iron and coke pig iron there will be made in this article no attempt to draw comparisons between the two. Each one will be treated independently and by itself. Each type of pig iron has its own place and there is little question but what a ready market will be found for the sale of charcoal pig iron if the manufacturers of this self same article are willing to place it on a competing basis as regards price, with that of coke pig iron.

Regarding the last point, such a condition is almost true at the present writing for the selling price of charcoal iron in Chicago today is but $16.50 a ton while the selling price of coke pig iron in the same center is $14.00 per ton.

That there can be but little profit in the manufacture of either product when the investment necessary for the business is considered and the amounts of off iron which are made of necessity no matter how carefully the smelting is watched, may be gleaned by studying the following cost sheets.

Charcoal pig iron.		Coke pig iron.	
Ore, 2.05 tons at $2.50	$5 13	2.05 at $2.50	$5 13
Charcoal or coke, 90 bu. at $0.06	5 40	1.1 at 4.50	4 95
Stone, .25 tons at $1.00	25	.5 at 1.00	50
Operating and repairs	2 50		1 25
Freight	1 50		....
Cost per ton of pig iron at Chicago	$14 78		$11 83

Because of the diversity, however, each type of iron will be given its own respective place.

CHARCOAL FURNACES.

With the selling price of pig iron as it is at the present time there is absolutely no question but were the by-product values of wood disregarded there would be no manufacture of charcoal pig iron in Michigan today, for if there was, the industry would be carried out at a loss and such a condition could not long exist.

Every charcoal plant operating today either owns its by-product recovery plant or else it is in such close union with a plant getting by-product values from wood as to be assured of a definite and regular supply of charcoal at a reasonable figure; the cost of the charcoal varying as the price of the charcoal pig iron varies.

There are two types of kilns extensively used in manufacturing charcoal. The one is a beehive kiln capable of containing from 60 to 90 cords of wood at a time, and producing approximately 45 bushels of charcoal per cord of wood. The operating cost for making charcoal is approximately 1½c per bushel and a kiln of this type will cost approximately $600.00. It takes 30 days to "turn" a kiln. By "turning" is meant the filling of the kiln, the carbonizing of the wood, the cooling of the wood and the discharging of the wood from the kilns. In a retort kiln, wood is placed on steel buggies or carriers which hold from 8 to 10 cords. The loaded buggy remains in the retort chamber for 24 hours, after which time the heat in the retort has driven out all the volatile matter and has carbonized the wood. The retorts are steel chambers 47′ long, 96″ high and 78″ wide. They are heated by the combustion of otherwise useless waste gases that come off from the carbonizing of the wood and likewise in emergencies they can be heated by the burning of wood. Combustion takes place in a chamber surrounding the retort. The flame does not hit the wood in the retort but heat is transmitted to the wood by radiation. This is directly the reverse of the action which takes in the beehive kiln where a certain quantity of the wood in the kiln is burned, solely for the purpose of giving enough heat for the carbonizing of the rest of the wood in the kilns.

Most all of the furnaces are hand filled, the one exception being Pioneer No. 2 Furnace at Marquette. Likewise in most all of the plants the stock house and stoves and storage bins are placed under shelter. This is primarily due to the fact that because of the cold, particularly with regard to the stoves, it has been found advisable to have them covered up, for in so doing a considerable loss of heat due to radiation is avoided. The covering of the stock bins is to prevent the ore from freezing as much as possible. It has been found cheaper to cover up these stocks of ore than it has been to keep gangs of men busy all winter digging out the frozen ore. This can be done somewhat more handily than it can in the case of furnaces making larger tonnages of pig iron; for with charcoal furnaces a storage stock house capacity of from 60,000 to 75,000 tons is all that is necessary, while in some of the larger units that are making pig iron in the Pittsburg or Chicago districts storage capacities of from 750,000 to 1,500,000 is hardly more than adequate. Shelter storage bins for tonnages of this latter type is, of course, out of the question. It was interesting to note that the stoves of the Mitchell-Diggins Iron Company at Cadillac were unprotected, and Mr. Lamoureaux, the Superintendent of that plant, stated that he experienced no difficulty in getting what heat he wished from the stoves.

Throughout, all of the charcoal furnaces cast in sand. For the most part the tapping hole is hand plugged rather than with a Gunnell's gun.

ANTRIM IRON COMPANY.

The Antrim Iron Company was organized in Michigan in 1886 with a capital stock of $350,000.00. Its officers are W. Bernhardt, President; J. C. Holt, Vice President and Treasurer; H. J. Bennett, Secretary; and N. M. Langdon, Manager.

The furnace was built in 1883 or 1884 by Mr. Otis, who was financially backed by Mr. Cherry of Chicago. On the latter gentleman's failure in 1884-5 the plant went into the receiver's hands, with Mr. Bernhardt as receiver. Mr. Otis, however, was permitted to pull the furnace out of the hole. Mr. T. J. O'Brien was President of the Company from that time until he resigned to enter the United States diplomatic circles as Minister to Japan.

Regarding the furnace proper, it is 60′ high and it has a 12′ bosh; the diameter of the throat is 7′ and of the hearth is 6′, with a hearth depth of 6′. It is hand filled and is capable of producing 115 tons of pig iron per day; but because of dull market conditions but 80 tons of pig iron is being produced daily at the present writing. It has 8 twyeres, and the diameter of the blow pipes at the nozzle of these twyeres is 4 inches. The blast pressure varies from 5 pounds to 7½ pounds to the square inch; an increase in blast pressure of necessity implying an increase in pig iron production. About 6,500 cubic feet of air is blown into the furnace per minute, and an average of 91 bushels of charcoal is used per ton of pig produced.

There is one double Durham iron pipe stove which heats the blast up to about 900° F. There are 18 U-pipes in the stove. There is also a spare stove. The blast is furnished by one vertical Weimer blowing engine, with a piston displacement in the blowing tub of 72″ x 48″. There are 6-150 H. P. and 2-200 H. P.

Wicks vertical water tube boilers. These are both gas fired with waste gases from the blast furnace and wood fired.

The charcoal is obtained from 56-55-cord beehive charcoal kilns, and 20-80 cord charcoal kilns of the same type. Wood alcohol and acetate of lime is secured from the volatile matter given forth in the carbonizing of the wood. Connected with the plant is a saw mill wherein the best of the lumber cut is sawed into shape and sold for building purposes.

EAST JORDAN FURNACE COMPANY.

The East Jordan Furnace Company was organized in Michigan, November 24, 1909, with a capital stock of $375,000.00. Its officers are Charles H. Schaffer, President; F. B. Baird, Vice President; and W. J. Ellson, Secretary and Treasurer. The furnace is located at East Jordan, Michigan, on the Detroit and Charlevoix, and East Jordan and Southern Railroads.

A large portion of the plant came from Principio, Maryland. A plant had at one time been in operation at that point making charcoal pig iron, but because of market conditions and the failure to have at hand a supply of charcoal it had to be abandoned. It was bought en masse by Michigan parties and moved to East Jordan.

The height of the furnace is 60′ and the diameter of the bosh is 10′. The diameter of the throat is 6′ and of the hearth is likewise 6′. The depth of the hearth is about 6′ 6″. The furnace is producing daily at the present time about 60 tons of pig iron. It could produce more, but because of the present dull market and because of lack of fuel, as the chemical plant from which the company derives its charcoal can give them but enough for 60 tons of pig iron per day, it is unable at present to give a greater tonnage. The furnace is hand filled. It consumes approximately 93 bushels of charcoal per ton of pig. There are five twyeres, the nozzle diameter of the blowpipe being 4½″.

Connected to the furnace are two 3-pass stoves, each one of which is 60′ high and 16′ in diameter. The blast is heated to from 950° F. to 1,100° F. Stoves are changed every 1½ hours. The blast pressure is 3½ to 4 pounds. The blast is furnished by a Weimer blowing engine which makes from 15 to 17 revolutions per minute. From 7,500 to 8,000 cubic feet of air is supplied to the furnace per minute. For generating power there are 6-250 H. P. water tube boilers of the Wicks type. Blast furnace gas and refuse from the saw mill is used as the boiler fuel.

The charcoal used in the furnace is obtained from the East Jordan Chemical Company. This company have 14-8-cord retort kilns and make the usual by-products from the wood consisting of wood alcohol and calcium acetate. The furnace plant is in no way connected with the chemical plant, but the chemical plant is under contract to supply to the furnace plant a definite amount of charcoal, and this feature assures the furnace company the supply of charcoal necessary for its operation.

LAKE SUPERIOR IRON AND CHEMICAL COMPANY.

The Lake Superior Iron and Chemical Company was organized in July, 1910, under the laws of the State of Michigan, with a capital stock of $10,000,000.00. Its present officers are John Royce, President; W. H. Matthews, Vice President and General Manager; L. F. Knowles, Secretary; and A. Van Oss, Treasurer. It is a consolidation of many of the charcoal plants scattered throughout Michigan, and it is putting many modern methods and practices into the manufacture of pig iron.

The company owns the Manistique furnace at Manistique, Michigan, the Newberry furnace at Newberry, Michigan, the Elk Rapids furnace at Elk Rapids, Michigan, the Pine Lake furnace at Boyne City, Michigan, the Chocolay furnace at Chocolay, Michigan, and the Hinkle furnace at Ashland, Wisconsin. With regard to the furnaces in Michigan but one, the Pine Lake stack, is operating at the present time. The Hinkle furnace is also operating but as its location is outside of the State it will not be treated or spoken of at further length in this article. The Manistique and Newberry and Elk Rapids furnaces will probably be blown in within the next few weeks, however. Extensive repairs and changes have been going on at these two plants and that fact for the most part accounts for their present idleness. The Chocolay furnace is so old and antiquated that it is extremely doubtful if it will ever again see further operation.

CHOCOLAY FURNACE.

The Chocolay furnace is an old stone stack formerly owned and operated by the old Lake Superior Iron and Chemical Company —now known as the Northern Iron and Chemical Company—and acquired in July, 1910, by the present Lake Superior Iron and Chemical Company. It formerly had an open top and boilers were placed on a fourth floor in order to more efficiently use the waste heat from the furnace. It has been owned by many different parties and it has been rebuilt and remodelled a great many times. From its early erection, however, it has proved to be a failure from a business standpoint. As soon as the present parties bought it they shut it down and it will not be operated until such a time as the price of pig iron rises to a point where a profit in its operation can be assured.

The stack itself is 40′ high and has a bosh 8′ in diameter. It is capable of producing 70 tons of pig iron per day. The blast is heated by means of two small Durham iron pipe stoves. The old blowing engine, has a piston displacement of 48″ x 72″ and makes from 11 to 13 revolutions per minute.

When operating it made car wheel and malleable pig iron, using charcoal as its fuel.

ELK RAPIDS FURNACE.

The Elk Rapids furnace, at present owned by The Lake Superior Iron and Chemical Company, is located on the Pere Marquette Railroad at Elk Rapids, Michigan. The furnace proper has been out of blast since early in the spring of 1911. Since that time, however, remodelling changes have been going on and it is very probable that the early spring will see the furnace in operation again.

The stack itself is 64′ high and it has a 12′ 6″ bosh. The throat is 7′ in diameter and the hearth is 6′ 3½″ deep and 7′ 6″ in diameter. Connected to the furnace are two iron stoves, one is 18′ x 28′ and another 18′ x 24′; each one has 21 pipes. There is one Weimer blowing engine having a capacity of 8,000 cubic feet per minute, also there is one old engine with a capacity of from 5,000 to 6,000 cubic feet per minute. Power is derived for the running of the blowing engines, pumps, etc., by four return type tubular boilers of 100 H. P. each.

Located close to the furnace are 60-60-cord beehive charcoal kilns. These make the charcoal used in the blast furnace and likewise furnish the volatile gases from which the chemicals such as wood alcohol and calcium acetate are obtained.

MANISTIQUE FURNACE.

The Manistique furnace, located as it is at Manistique, Michigan, has excellent railroad facilities by being on the lines of the Chicago, Milwaukee, and St. Paul, Sault Ste. Marie, and Ann Arbor Railroads. This stack was originally built by the Perry Chemical Company about 1890 and was acquired in 1910 by the present Lake Superior Iron and Chemical Company.

It has been out of blast since June, 1910, but it will probably go in blast again about June, 1912. Extensive changes have been made in the plant, and by the time it is ready to go in blast it will, without doubt, be one of the best equipped charcoal pig iron plants in the country.

The furnace is 59′ 6″ high with a 12′ 6″ bosh diameter. The diameter of the throat is 7′ 6″ and of the hearth is 7′, with a hearth depth of 5′ 4″. Its rated daily capacity is from 110 to 120 tons of pig iron. The furnace is hand filled. The blast is heated by Durham hot blast pipe stoves which heat the air up to approximately 960° F.

Its blowing engine is of the Nordberg cross compound horizontal type with a rated capacity of 10,000 cubic feet per minute. There is also a Weimer vertical engine which has a capacity of 8,000 cubic feet per minute. The furnace proper will use about 7,600 cubic feet of air per minute under a pressure of 6½ pounds. Six Wicks vertical water tube boilers furnish a total of 1500 H. P. for the running of the blowing engines, pumps, and the other mechanical appliances around the furnace. They are equipped so as to use the waste gases from the blast furnace.

As new installation there is being erected a charcoal kiln plant very similar in detail to that which is found at the Newberry furnace and which will be discussed at further length in the description pertaining to the Newberry furnace.

NEWBERRY FURNACE.

Located on the Duluth, South Shore and Atlantic Railroad, in the town of Newberry, is a charcoal blast furnace known as the Newberry furnace. In 1910 this was acquired by the Lake Superior Iron and Chemical Company. It has been erected for a considerable period and has been in operation off and on for many years. Extensive repairs and alterations have been made recently and in fact are still being made. It is the expectation that about February 1st it will be in such shape as to permit its being blown in.

The furnace is 60′ high with a 12′ bosh; the diameter of the throat is 7′ 6″ and of the hearth is 7′ 6″. The height of the hearth is 6′. It is hand filled and has a capacity of 80 tons of pig iron per 24 hours. There are four twyeres, each one of which has a diameter at the end of the blow pipe of 4″. It is expected that about 87 bushels of charcoal or the equivalent of two cords of wood will make a ton of pig iron.

Attached to the furnace are two Durham iron pipe stoves, each one of which has 16 pipes. It is the intention to heat the blast to a temperature of 950° F., and use a pressure of 5½ pounds. The blast is furnished by one Nordberg cross compound horizontal engine having a capacity of 10,000 cubic feet. There is also a Weimer blowing engine of 8,000 cubic feet capacity that can be used as a spare. In the boiler house are found 8 horizontal tubular boilers giving a total of 1,200 H. P.

When completed this plant will be equipped so as to get to as great an extent as possible all of the values that are found in the wood. Timber is brought to the company's saw mill and there sawed and such pieces as are of proper grade are sold for building purposes. The refuse from the mill, consisting as it does of odd ends, sides, and slabs too small for sale as lumber, are taken to the company's charcoal ovens for conversion into charcoal, wood alcohol, and calcium acetate.

The old plant consisted of 54-100-cord brick charcoal kilns. In using these it takes about 30 days to fill, fire, and turn a beehive charcoal kiln. The entire process is known technically as "turning." These kilns will still be used but only to a limited extent. In fact they will only be used for the using up of the large wood.

The new installation consists of 20 retort kilns which are capable of daily carbonizing 160 cords of wood. Such an installation makes this the largest charcoal retort kiln plant in the world. Besides the 20 retort burning kilns there are 40 retorts for cooling, 20 of which are for the hot coals and 20 for the cooler coals. In cold weather it will probably be necessary to operate but the first set of coolers. Each retort is 47′ long, 78″ wide and 96″ high. The volatile gases as they come from the burning of the wood give a light distillate which is essentially wood alcohol and also a heavy distillate. This latter product by further distillation gives tar and a product which, when treated with lime, gives calcium acetate. For the purpose of carrying out the chemical action a modern by-product recovery plant is now nearing completion.

PINE LAKE FURNACE.

Formerly owned by the Boyne City Iron and Chemical Company, this furnace which is located at Boyne City was acquired in 1910 by the Lake Superior Iron and Chemical Company. It is located on the Boyne City and Southeastern Railroad. It is the one furnace owned by the Lake Superior people, of all those located in Michigan, which is at present in operation.

The pig iron plant proper, which we are chiefly interested in, consists of a furnace, cast house and stock house. The stack is 62′ 9″ high with a bosh 12′ in diameter. The diameter of the throat is 6′ 6″ and of the hearth is 7′ 2″. The depth of the hearth is 6′ 8″. The furnace has two 2-pass brick stoves, each one of which is 60′ high and 12′ in diameter. It has a vertical blowing engine of 8,000 cubic feet capacity of the Waddington, McConnell, and Stevenson type. There are also three Wicks boilers furnishing a total of 750 H. P.

The furnace, which was originally blown in on January 1st, 1904, was in almost continuous blast for a period of 6 years and 8 months from that time. It was blown out on September 1st, 1911, for relining, but was blown in again on December 5th, 1911. The rate of daily output of the plant is 80 tons, and 88 bushels of charcoal are used per ton of iron made. The furnace is tapped every six hours. The limestone used is that obtained from the Petoskey Crushed Stone Company. Old range ores make up the basis of the burden. A charge at this furnace consists of two buckets of ore (1,250 pounds), two buckets of charcoal (500 pounds) and 60 pounds of stone.

The charcoal used comes from that furnished by the Boyne City Chemical Company. At the plant of this latter company there are 14 retort kilns of 10 cords of wood capacity each. But for the stunted supply of charcoal at the furnace there is little doubt but what the furnace could raise its daily capacity to a much higher degree than that stated in a preceding paragraph.

MITCHELL-DIGGINS IRON COMPANY.

In 1904 the Mitchell-Diggins Iron Company was organized in Michigan with W. W. Mitchell, President; J. C. Ford of Fruitport, Vice President and Secretary; and Fred A. Diggins, Treasurer. The plant is located at Cadillac on the Grand Rapids and Indiana and Ann Arbor Railroads.

This plant, more than all others at present making charcoal pig iron, is strikingly similar to coke blast furnaces. This feature is probably accounted for because Julian Kennedy, a prominent coke blast furnace engineer, was the designer of this plant. Its erection at Cadillac is accounted for by the fact that there are two large saw mills at that point and two wood chemical plants known respectively as the Cadillac Chemical Company and Cummer-

Diggins Company. These firms had no adequate outlet for the charcoal which they produced as a by-product to the wood alcohol and calcium acetate values, and in consequence they assured the builders of the furnace plant a reasonable supply of charcoal at a reasonable cost if the furnace would take off their hands the supply of charcoal which they are continually making.

The stack has a height of 65′ and a bosh diameter of 11′ 4″. The diameter of the throat is 7′ 6″, the diameter of the hearth is 7′ 8″ and the depth of the hearth is 6′. There are five twyeres, each one of which has a blowpipe diameter at the nozzle of 4″. The blast pressure is about 6½ pounds. The capacity of the furnace is from 90 to 100 tons of pig iron per day.

The stoves, which are three in number, are 60′ high and 16′ in diameter and are of the Kennedy 2-pass type. They are exposed to the air and are the only charcoal stoves in Michigan which are constructed without shelter. The stoves are changed every two hours and the blast is heated up to from 1,100° to 1,250° F. There are three boilers, each one of 250 H. P. They are of the K. Hall horizontal type, and are equipped for using the waste gases from the blast furnace and likewise for burning coal. The blast is furnished by one Tod vertical blowing engine, with a rated capacity of 10,000 cubic feet per minute.

THE PIONEER IRON COMPANY.

This is one of the oldest pig iron producing companies in Michigan for it was on April 2nd, 1857, that the company was organized with a capital stock of $125,000. It is a subsidiary to the Cleveland-Cliffs Iron Company. The officers at the present writing consist of G. A. Garretson, President; Wm. G. Mather, Vice President; E. V. Hale, Secretary; F. A. Morse, Treasurer; R. C. Mann, Auditor; and Austin Farrell, General Manager. The Board of Directors is made up of Wm. G. Mather, E. V. Hale, G. A. Garretson, J. H. Hoyt, Samuel Mathers and J. H. McBride.

This company controls three furnaces, two near Marquette and one at Gladstone, Michigan. Two of the furnaces are active; the one at Gladstone and one at Marquette. Detailed information in regard to these furnaces is found below.

CARP RIVER FURNACE.

In 1905 the Pioneer Iron Company purchased from Schaffer and Gray a blast furnace, located at Carp River, that is known as the Carp River Furnace. It was operated continuously throughout

the years 1905, 1906 and 1907, making a brand of iron that is known as "Excelsior." It has not been operated since, however, because of the low price that charcoal pig iron has been bringing the past few years. In fact, it is quite probable that the furnace will never see further operation again as it is not equipped with many of the modern appliances and thus is in a condition preventing it from making pig iron at an economical figure. In fact the price of the iron would have to undergo a marked rise before its blowing in would be warranted.

The furnace itself is 58′ high and it has a bosh 10′ in diameter. It is filled by hand and is capable of producing about fifty tons of pig iron per day.

The fuel used is charcoal obtained from the company's beehive charcoal kilns of which there are 43 in number.

NO. 1 FURNACE AT GLADSTONE.

This furnace was built in 1896 by the Pioneer Iron Company at Gladstone, Michigan, but a short distance from Lake Michigan and near the port of Escanaba.

The furnace itself is 60′ high and has a bosh 12′ in diameter. It has a rated daily capacity of approximately 110 tons of pig iron, the brand of which is known as "Pioneer." The furnace is filled by hand and has a single bell with a Weymer seal. It uses 4 pounds air pressure, has five twyeres with a 5″ diameter blowpipe nozzle. Connected with the furnace are three Roberts-Cowper stoves, each one approximately 70′ high and 16′ in diameter.

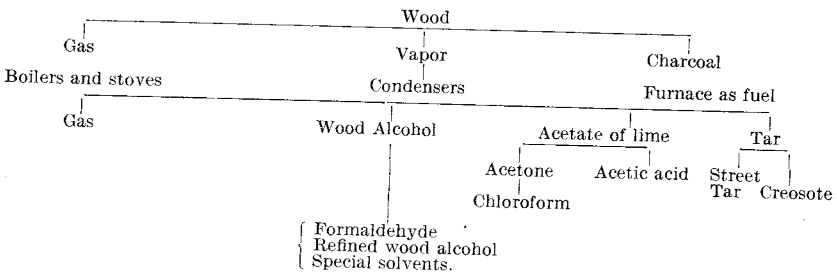
As a fuel the furnace uses charcoal obtained from 70 beehive charcoal kilns and 10 retort kilns. The wood put into the kilns is cut by the company's lumbering department. The smoke caused by the manufacture of the charcoal is used in the company's chemical plant for the production of various chemical products, chief of which are acetate of lime and wood alcohol.

NO. 2 FURNACE AT MARQUETTE.

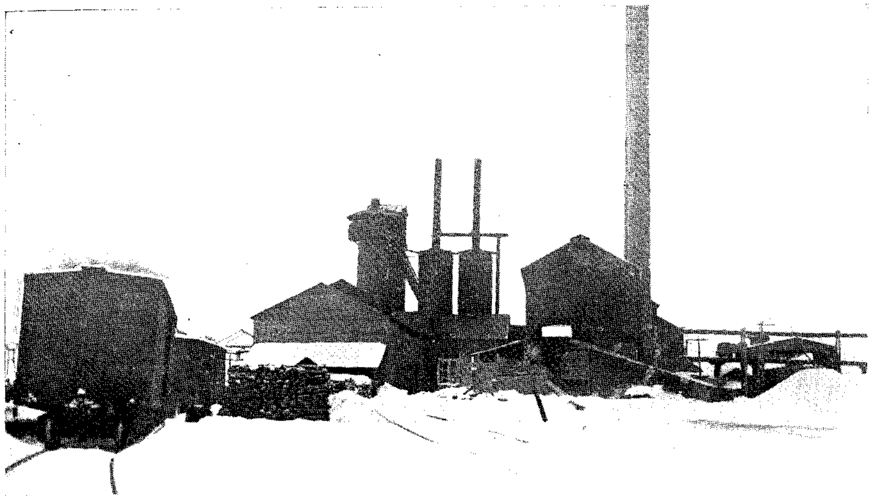
This furnace was erected in 1903 by the Pioneer Iron Company, a subsidiary of the Cleveland Cliffs Iron Company. It is built very closely along the line of the company's furnace at Gladstone. The plant, however, is somewhat more modern and has several improvements, chief of which is Gayley's dry blast.

The furnace itself is 70′ high and has a 13′ bosh. It averages about 120 tons of pig iron per day, making a brand known as "Marquette." A blast of 6½ pounds pressure is carried which gives a volume of 7,000 cubic feet per minute. The air is supplied by a double cross compound Southwark engine. The furnace is skip filled and has a Roberts revolving top. Connected with the furnace are three Roberts-Cowper stoves, each one 70′ high and 16′ in diameter. When but two of these stoves are used they are changed every two hours while with three stoves in use they are changed every 1½ hours. They heat the blast to a temperature ranging from 1,000° to 1,100° F.

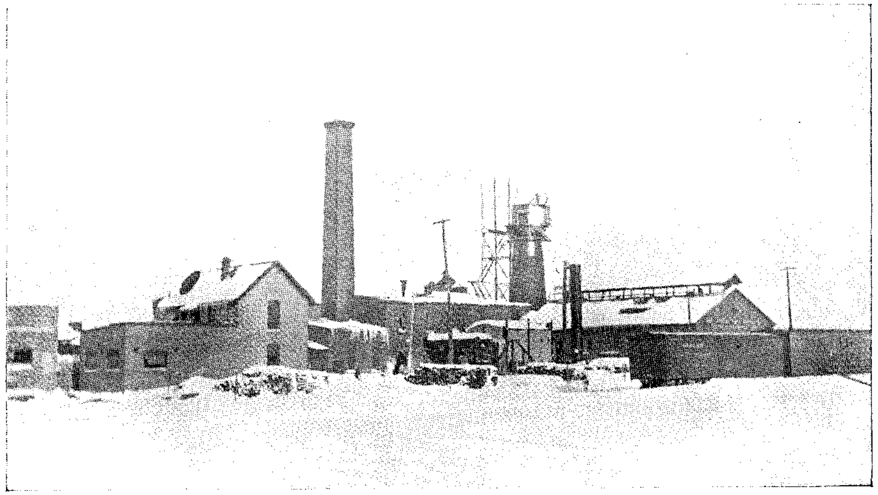
For fuel charcoal is used, obtained from 86 kilns operated by the company and which are filled with wood cut by the lumbering department of the Cleveland-Cliffs Iron Company. Of the kilns there are 80 that are known as 80 cord kilns, each one of which is capable of producing about 3,500 bushels of charcoal per turn, and there are 6 kilns with a capacity of 90 cords capable, therefore, of producing a somewhat larger quantity of charcoal. The smoke coming from the kilns as the result of a charring of the wood is converted into various chemical by-products, chief of which is alcohol, formaldehyde, acetone and acetic acid. The flow sheet of a portion of this particular conversion which may be of interest is as follows:



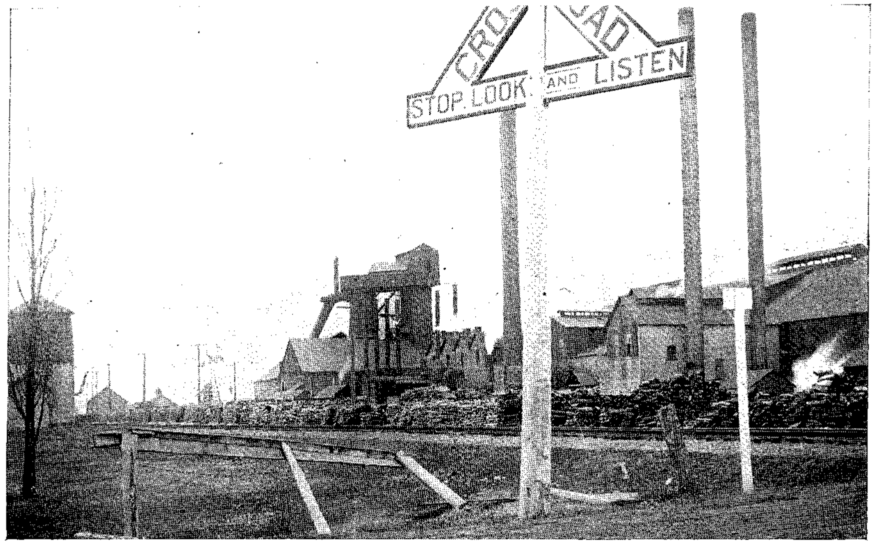
In 1910 the plant was equipped with a Gayley dry blast, not so much for the purpose of reducing the charcoal consumption in the blast furnace as to enable the furnace operator to have uniform conditions in his furnace and thus assure the management of a uniform quality of pig iron. The expense attached to the installation seemed justified, for with pig iron selling at such a close margin it was necessary to take advantage of all methods which would tend toward the assurance of a uniform and standard quality of pig. At the present time about 92 bushels of charcoal are used per ton of pig iron produced.



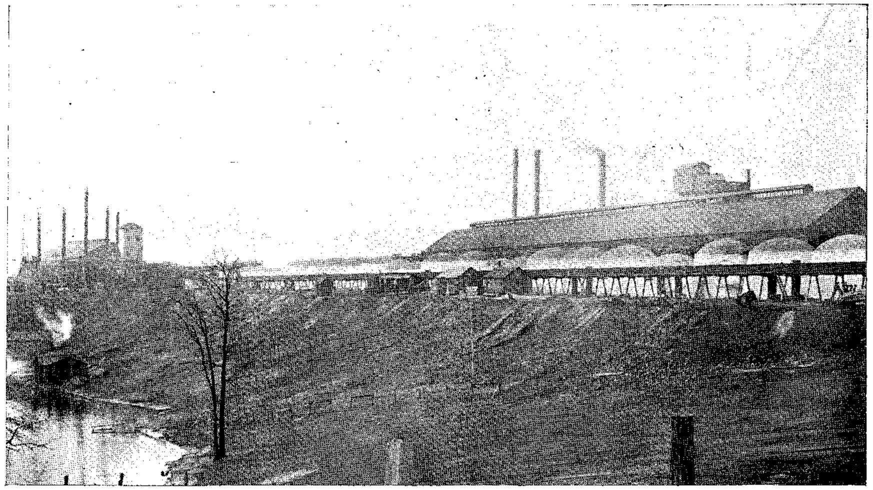
A. EAST JORDAN FURNACE.



B. NEWBERRY FURNACE.



A. ANTRIM IRON FURNACE.



B. FURNACE AND CHEMICAL WORKS, ANTRIM, MICHIGAN.

The ores are some of those mined by the Cleveland Cliffs Iron Company at its various mines located in northern Michigan. They are of the high grade Old Range type and when dry contain 60% iron. .26 tons of slag are made per ton of iron produced.

SPRING LAKE IRON COMPANY.

In 1879 the Spring Lake Iron Company was organized in Michigan with a capital stock of $30,000. A furnace was erected at Fruitport, Michigan. At this point direct connections by water can be had with Chicago, Milwaukee, and other distributing centers. The officers of the company are J. C. Ford, President and Treasurer, and Frank F. Bowles, Secretary.

The stack proper is 50′ high and 11′ in diameter at the bosh. The blast is heated by iron pipe stoves. The capacity of the furnace is about 75 tons of pig iron per 24 hours.

At present the plant is not in operation. This is in large measure due to the present dull condition of the pig iron market. In addition the furnace needs extensive alterations before further production can be carried out. These alterations and repairs will be made as soon as an improvement in the pig iron market conditions warrant.

STEVENSON CHARCOAL IRON COMPANY.

The Stevenson Charcoal Iron Company was organized on June 9, 1911, with a capital stock of $150,000.00. The plant is at Wells, Michigan and for transportation purposes is extremely well located, as it is on the Chicago and Northwestern; Chicago, Milwaukee and St. Paul; and Sault Ste. Marie Railroads. The officers of the company are Charles H. Schaffer, President; Grant T. Stevenson, Vice President; and J. R. VanEvera, Secretary and Treasurer.

The erection of the plant at that point was in order to utilize the vast quantities of charcoal that are being produced there daily by the Meshek Chemical Company. It is expected that the furnace, which is now in process of erection, will be completed so that it can go into blast about July 1, 1912. The stack proper is 60′ high and has a bosh 10′ in diameter. It will produce about 60 tons of pig iron per 24 hours. Connected to the furnace are two fire brick stoves. There is also at the plant the usual apparatus consisting of such things as a blowing engine, pumps, boilers, etc.

COKE FURNACES.

Of the coke blast furnaces in Michigan there are three in number, and all, strange as it may seem, are located within the bounds of Detroit. One controlled by the Detroit Furnace Company has rather a small tonnage and resembles to a great extent a typical charcoal furnace in that it uses pipe stoves, is hand filled, and is of small capacity.

The two furnaces of the Detroit Iron and Steel Company are located on Zug Island, are in every way modern, and as far as operative costs are concerned should make pig iron at nearly as low figures as any pig iron plant in the country.

It is very probable that there will be no further coke furnaces erected within the bounds of the State for a number of years; largely because there is no great iron consuming center other than Detroit, and it is very probable that for many years to come there will be no one portion in Michigan which will rise to such an industrial condition as to be a large and important pig iron consuming center.

DETROIT FURNACE COMPANY.

The Detroit Furnace Company was organized on April 1st, 1906 with $150,000.00 capital stock. Its officers are J. C. Clutts, President; J. K. Pollock, Vice President; and C. F. Fraser, Secretary and Treasurer. The furnace plant itself has been built and in operation off and on for over 40 years. It was formerly controlled by the Wayne Iron Company, and up to the time of its purchase by the Detroit Furnace Company charcoal was the fuel used. The present management have, however, run it with coke, and this furnace, together with the two of the Detroit Iron and Steel Company, comprise the three furnaces which use coke in the production of pig iron in Michigan.

The furnace itself is 62′ high and has a bosh diameter of 12′ 6″. The throat diameter is 7′ 4″ and the hearth diameter is 7′ 6″. The depth of the hearth is 7′ 8″. It has 7 twyeres, the blowpipe nozzle diameter of which is 3½″. The blast pressure ranges from 5 to 7 pounds, and about 7,000 cubic feet of air is blown into the furnace per minute. The stated capacity of the furnace is about 75 tons of pig iron per day, and approximately 2,500 pounds of beehive coke is consumed in producing a ton of pig iron. About 1,650 tons of slag is made per ton of pig. The furnace is hand filled.

Connected to the furnace are three U-pipe stoves wherein the blast is heated from 600° to 850° F. The blast is supplied by 1-500 H. P. Weimer vertical blowing engine. The boiler installation consists of 5 horizontal Brownell boilers of 150 H. P. each.

DETROIT IRON AND STEEL COMPANY.

The erection of the plant of the Detroit Iron and Steel Company was the first important endeavor to locate within the bounds of Michigan a modern and up-to-date blast furnace plant in which coke was to be used as the metallurgical fuel. The company had its origin on April 24, 1902. There has been an issuance of $750,000 of preferred stock and $750,000 of common stock. The officers of the company are D. R. Hanna, president; F. B. Richards, Vice President; R. L. Ireland, Vice President; C. W. Baird, Secretary and Treasurer; Max McMurray, General Manager; and P. J. Moran, Superintendent.

The plant is located on Zug Island and lies between the River Rouge and the Detroit River. Such a location enables ore to be unloaded directly at the furnace. It has direct connections with the Michigan Central; Detroit, Toledo and Ironton; Detroit and Toledo South Shore; Wabash; Pere Marquette; and Canadian Pacific Railroads. Connections to these last three are via. the Delray Connecting Railroad.

There are two stacks at the plant, one known as "A" furnace and the other known as "B" furnace. "A" furnace was built and put in blast about 1902, while "B" furnace was not erected and put in blast until July, 1910.

"A" furnace is 78′ high, 18′ 8″ at the bosh, 12′ 6″ at the throat and 13′ at the hearth. The depth of the hearth is 6′. It has 10 twyeres, the diameter of the blowpipe nozzle of which is 5″. This furnace produces a tonnage of approximately 300 tons of pig iron per day and in doing so consumes from 2,200—2,400 pounds of by-product coke per ton of iron. From 27,000 to 30,000 cubic feet of air is blown into the furnace per minute under a pressure of approximately 13 pounds. The blast is heated to a temperature of about 1,000° F. To do this there are 4 Garrett-Cromwell 2-pass brick stoves, each one of which is 83′ high and 20′ in diameter. The furnace was in continuous operation from the time of its erection until June, 1911, when it was taken off for repairs. At that time it had a ⅜″ shell with a 42″ brick lining. Since that time the stack has been entirely rebuilt and it has now a ¾″ shell with a 12″ lining. The stack is water cooled above the mantle, however. In addition to the water spray, 6 rows of bosh plates are in use.

"B" furnace, which was put into blast for the first time in July, 1910, has a ¾" shell with a 48" brick lining. The stack proper is 80′ high. The diameter of the bosh is 18′ 6″, the diameter of the throat is 12′ 6″, the diameter of the hearth is 12′ 6″, and the depth of the hearth is 7′. The furnace makes approximately 325 tons of pig iron per 24 hours and in doing so consumes from 2,000 to 2,200 pounds of beehive coke per ton of pig. 32,000 cubic feet of air is blown into the furnace per minute at a pressure of about 13 pounds and at a heat varying from 1,100° to 1,200° F. There are 12 twyeres 5″ in diameter at the nozzle of the blowpipe. The furnace is equipped with four Nelson-McKee 2-pass brick stoves, each one of which is 85′ high and 12′ in diameter.

Both furnaces are skip filled, "B" with a steam hoist and "A" with an electric hoist. Attached to "A" furnace is 1 large dust catcher, while attached to "B" furnace is 1 large dust catcher and 1 Mullin gas washer.

The blast is furnished by 5 blowing engines. On "B" there are two Allis blowing engines, each one 84″ x 60″. They are both of the long cross head disconnected compound type. On "A" there are two high pressure and one low pressure engine of the long cross head type. These last were made by the Tod Blowing Engine Company. Altogether there are 13 boilers at the plant; 8 are on "A" and 5 are on "B," giving a total of 2,000 H. P. The 8 "A" boilers are of the Babcock and Wilcox type, and the 5 "B" boilers are of the Wicks vertical type. Electric power is furnished by 1 Bullock 300 K. W. generator and 3-Elell-Parker generators of 200 K. W. capacity each.

The casting of the pig iron is done both in sand and in a Uehling single strand pig casting machine. The length of the strand, c to c, is 140′. In the cast house there is one Brown pig breaker.

For the handling of the raw materials and especially for the unloading of the ore from the boats there have been installed two Wellman-Seaver unloaders, each one of which has a capacity of 200 tons per day. There is also one Brown hoist unloader, with a daily capacity of 300 tons. These unloaders remove the ore from the boats, transfer it to stock bins and do other miscellaneous work.

The ores used at the furnace are of the Old Range and Mesaba grades, with an average iron content of about 51½%. "A" furnace uses by-product coke obtained from the Solvay Process Company's plant which is located just across the river, and "B" furnace uses Connellsville beehive coke.

THE J. T. JONES' STEP PROCESS FOR THE METALLIZATION OF LOW GRADE IRON ORES.

BY ALBERT E. WHITE.[1]

At the present writing there is probably no more interesting experiment being carried on, than that which Mr. J. T. Jones is conducting at Republic, Michigan. The experiment proper consists in the endeavor to convert into a commercial product the vast quantities of low grade iron ores which are found on the Marquette, Menominee, Gogebic, Vermilion, and Mesaba Ranges; but especially those found on the Menominee and Marquette Ranges. Mr. Jones has been working on this experiment since September, 1908. He has spent vast sums of money in carrying out his ideas and in making such changes as became necessary from time to time and there is little doubt but what in a very few months the results of his work will be definitely known, and one can then be certain as to whether or not the metallization of low grade iron ores will prove to be a commercial success.

Before proceeding further it should be made clear that it will probably become true that the Jones process will not be applicable to all types of low grade iron ores found on the iron ranges, but only to those possessing certain definite characteristics. In spite of this narrowing of the proposition, there is little question but what his process is applicable to extremely large quantities of iron ore, and for that reason it is the writer's belief that the vast sums of money which have already been spent are altogether warrantable. This narrowing of the process is but following the common law of all ore dressing operations, for in all work of this nature there is no one process or no one portion of a process which is applicable to all grades and types of ore.

Not since the early days when steel was made in this country in a Bessemer converter for the first time, at Wyandotte, Michigan, has an experiment been carried on containing such possibilities. There has never been an experiment carried on in the borders of this State which, if successful, will mean more to this State than the experiment which Mr. Jones is doing at Republic, and

[1] Instructor in Chemical Engineering University of Michigan.

which had its origin and the beginning of its development at Iron Mountain. It is a process and a scheme which is worthy of the kindest criticism and which is well worth being financially backed for the possibilities of financial returns which it possesses.

The experiment in brief is to take low grade iron ore and by bringing it into contact with the volatile matters of coal or wood and likewise the fixed carbon which is found in the coal or wood it is expected that the oxygen will be driven out of the iron oxide of the ore leaving the iron in the ore in a metallic condition without in any way fluxing or melting the iron or gangue found in the ore—and then by a process of magnetic concentration the iron will be freed from its gangue and there will be obtained as a result a product by all means fit for blast furnace use and possibly of such a high grade as to be acceptable for open hearth use.

It is true that Mr. Jones has met with considerable criticism with regard to the possibility of success for his proposition. Most of this criticism has come from men who have vast sums of money invested in blast furnaces and other modern steel making appliances and who regard his process as alien to their best interests rather than as a supplement to the present methods of iron and steel making now in vogue. Some have even gone so far as to condemn his proposition after but a very hasty and superficial glance at its possibilities and little if any weight should be given to such condemnation.

On the other hand there are many men who are warm supporters of Mr. Jones' idea. They realize the great hesitancy with which new schemes are first received. They further realize that at the start there are many factors which have to be met before any new proposition is worked out to a financial operating success.

Of course the crucial crux to the entire process lies in the amount of fuel which it will be necessary to consume in metallizing one ton of product. In an operation which Mr. Jones carried out last winter at Iron Mountain similar to the present one in principle although with a different type of roaster, 85 pounds of fuel was consumed per 100 pounds of product metalized. The inventor was taken sick and for a short period the writer handled the experiment and by judicial and careful work he was able to bring the fuel consumption down to 52 pounds of fuel per 100 pounds of product metallized. The writer, however, is of the firm belief that it will require but 40 pounds of fuel per hundred pounds of ore to bring about satisfactory metallization. In this

figure he is assuming the use of fixed carbon alone. Theoretically it requires but about 26% of soft coal to do the work necessary in metallizing, and with an allowance of 40% there is therefore 15% excess. Of course there is no question but what the volatile matters in coal will metallize ore providing you keep the ore in contact with the volatile gases for a sufficiently long period. Such a thing as this is extremely difficult to do on a commercial scale for the volatile gases always have a tendency to escape and at the present time there is no mechanical appliance known that is capable of keeping the gases and a product such as low grade iron ore in contact for a period sufficiently long to allow of the complete metallization of the ore. It is because of the difficulty of metallizing the hydrocarbons that the writer has based his calculations on the fixed carbon found in coal.

There is a further possibility of making use of the large quantities of waste wood that are found in the vicinities of the low grade ore deposits for the metallurgical fuel to be used in the reduction. Such a possibility as this is worth considering on a small scale. It cannot assume large proportions, however, because of the fact that the supply of wood in the State of Michigan is rapidly decreasing and it will be but a question of time before the entire supply is practically consumed. For that reason it is only just that the process when looked at from the larger aspect should seek its fuel from coal.

Mr. J. T. Jones was led to the idea of conceiving the process for the utilization of the low grade iron ores because of the immense tonnages which are found in the Lake Superior region and because of the immense possibilities which a successful method for the treatment of the ores possesses. Before arriving at a scheme of metallizing he threw aside practically all other methods capable of containing possibilities for the recovery of the values found in the low grade ores. It seems to the writer that for the most part he was quite justified in taking the attitude which he did, for he was chiefly interested in the ores which were found in the Menominee and Marquette districts. These ores are quite hard and recent experiment has shown that they are not treatable in accordance with the modern methods of wet gravity ore dressing or milling.

The inventor at first felt, that with the proper tools he could reduce the iron found in the low grade ores to a metallic sponge, keeping the temperature throughout this portion in the operation at a point below the melting point of both the iron and of the slag forming constituents. When in a metallized condition the product was then to be heated to a temperature sufficiently high to flux the gangue—gangue which for the most part was silica and which was to be fluxed with iron oxide—but at a temperature not hot enough to melt the iron. It was then to be the endeavor to squeeze out the liquid impurities from the pasty iron. After many trials, however, it was learned that there was no known means of getting a fire brick lining which would stand up under the fluxing action of the iron oxide present in the product. To carry out this idea Mr. Jones erected near his home at Iron Mountain a large kiln 120 feet long and 8 feet in internal diameter which was supplemented with such necessary accessories as crushers, crushing rolls, elevators, screens, etc. His idea at that time was to put the ore into the kiln at one end and have it come out at the discharge end in such a condition that the slag would be liquid and the metallized metal would be pasty, capable of immediate working into commercial muck bar. The difficulty with this scheme as stated above was the fact that the lining of the kiln would not withstand the fluxing action of the iron oxide. All types and kinds of fire brick were used, including such kinds as magnesite brick, chrome brick, silica brick, fire clay brick, etc., but to no avail.

His next idea was to keep the temperatures in the kiln down to such a point as would metallize the iron ore present, but which in no way would result in a melting of either the ore or the gangue. At almost the first attempt Mr. Jones succeeded in getting the type of product which he wished: a product wherein all the iron oxide present in the low grade ore was reduced to metallic iron. His difficulty here was the fact that there was too high a consumption of fuel and the formation of a ring in the tube caused continuous operation to be an impossibility.

In order to overcome the first difficulty Mr. Jones conceived the idea of allowing the volatile hydrocarbon gases in the bituminous coal to do the work. Such action, he felt, would result in a reduction of the iron oxide to a spongy metallic iron. It is from this step that the process called "metallizing" has derived its name. He had been able to carry out this idea in a crucible test, for without any difficulty whatever he had converted the iron in an iron ore to a metallic sponge and the bituminous coal from which he had derived the necessary hydrocarbons was converted into coke.

His great claim for the commercial success of the process lay in the fact that while he was converting the iron in iron ore to a

metal he was, at the same time, producing a merchantable coke which, because of its value, would, in itself, more than pay for this particular step in the process.

So far Mr. Jones has had considerable difficulty in metallizing in his long tube by means of the volatile hydrocarbons. In fact one can state that as yet he has never succeeded in metallizing on a continuous commercial scale by means of the volatile hydrocarbons. Mr. Jones himself is aware of this difficulty and initially for the purpose of overcoming it, he inserted a charging door in his kiln two-thirds of the distance in from the feed end. At that point he inserted bituminous coal. His idea was to first allow the ore to become hot by means of contact with the escaping gases and through the combustion of a small quantity of fuel which he fed in with the ore, and after the ore had reached the necessary heat—which may be expressed as dull yellow because of the color of the ore—he added to it the bituminous coal which would furnish the hydrocarbons necessary to carry out the reduction of the iron in the iron ore to a metallic sponge. This step in the process was to be accompanied by the production of coke, for it was the endeavor to have the heat sufficiently great to free the coal of its volatile matter but not great enough to burn or consume the coke made after the expulsion of the volatile matter from the coal.

In carrying out this idea, two difficulties were encountered. In the first place the chemical and heat action at the point where the coal was fed into the tube was so great as to cause a superabundance of heat at this point. This caused melting of the gangue constituents of the ore and likewise a certain quantity of the iron in the iron ore was made metallic at this point. This caused it to become pasty. These conditions caused the materials to cling to the sides of the kiln in this vicinity and within 23 hours after this type of charging was resorted to, further use of the tube had to be abandoned until the ring was cleared away. The second difficulty was the trouble encountered in getting the coal which was charged through the side door underneath the ore burden. It was impossible to revolve the kiln faster than one revolution in 20 minutes. The kiln was fed with ore varying in sizes of from 2″ pieces to as small as dust. The larger pieces went through the kiln at a much faster rate than the smaller pieces did. To secure complete metallization of the entire product, it was necessary to adjust the speed of the kiln to suit the larger pieces of ore. For that reason the slow speed had to be adopted. Because of the slow speed the ore as it passed down through the kiln slid rather than showered, and because of this sliding action it was impossible to get the coal which was fed through the side door underneath the ore burden. For that reason the most of the possibilities that lay in metallizing through the use of the volatile hydrocarbons could not be utilized.

As a result, it was true that in practically all of the long runs which were made at Iron Mountain, the fixed carbon in the coal and not the volatile hydrocarbons was the agent which did the metallizing.

Mr. Jones appreciates this difficulty. In the early part of his experiments he endeavored to put lifters inside the tube. The lifters did not last, however, because the two kinds which he used were not adapted for the idea; the first one being a fire brick which was mechanically too weak to stand up and the other a concrete one which was not adaptable to withstanding heat.

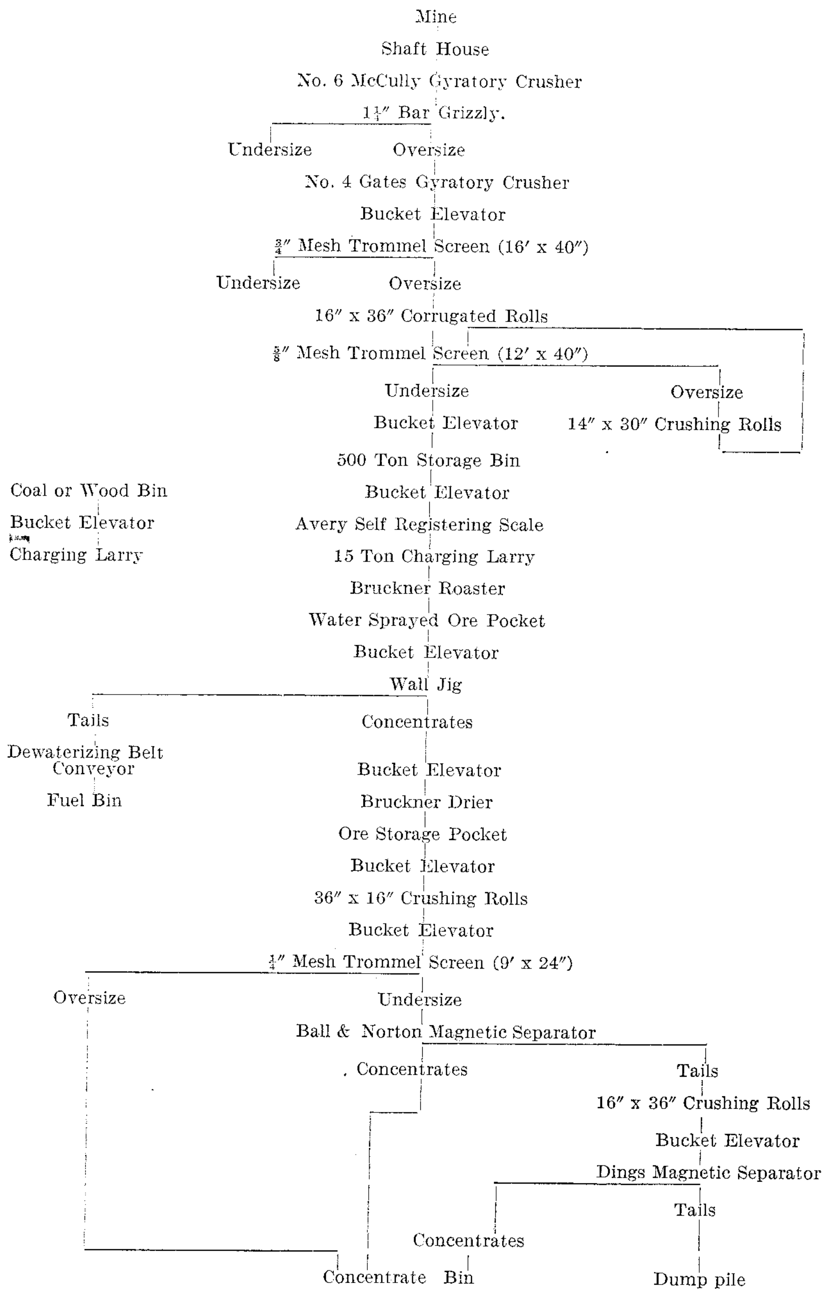
In order to meet this issue more effectively Mr. Jones began, last spring, the erection of a metallizing plant at Republic, Michigan. He located the plant at the shaft head of the Kloman Mine for it is from this particular mine that the ore to be treated will be obtained. Mr. Jones has met with considerable criticism for utilizing this ore in his metallizing experiments, as it is claimed that it is the ore of ores on the Menominee Range most adaptable for the process laid forth. There is no question but what this ore is of a type which can be treated successfully in accordance with the proposed process, if any ore can be so treated. It appeals to the writer as though such criticisms are somewhat unjust because there is no question but what Mr. Jones has enough available ore in this one property to warrant the entire expense to which he has been placed if his proposition works out successfully and a proposition ought to be developed along lines most favorable for its advancement.

At the present writing it is the intention to mine the ore in the Kloman property according to the Glory Hole system made use of so commonly in the western part of our country, especially in the mining of our low grade copper ores. The ore will be hoisted to the surface and crushed in a No. 6 McCulley Gyratory Crusher. It will then be sized on a 1½ inch bar grizzly and the oversize will be again crushed on a No. 4 Gates Gyratory Crusher. The whole product will then pass through rolls and screens until it is broken down to sizes ⅝ of an inch in diameter or smaller. The product will then be placed in Bruckner roasters, fifteen tons at a time, for the purpose of metallizing. These roasters are arranged

in series of two. One is metallizing the ore while the other is having the ore which is present in it heated up by the passage through it of the waste gases from the first roaster. After the product in the initial roaster is metallized the ore is then dumped into a water-sprayed pocket. Fuel is then added to the second roaster, likewise ore is added to the first roaster. Metallizing then takes place in the second roaster with the passage of the waste gases through the first roaster for the purpose of heating up the ore therein. The metallized ore from the pocket is passed to a jig for the purpose of removing any good merchantable coke which may be present. The concentrates are then carried to a Bruckner drier and from there are crushed to a proper size and then magnetically separated; with a final concentrate of such a grade as can be used in a blast furnace as an ore or else as a product for open hearth use.

The detailed flow sheet of this process is as follows:

FLOW SHEET OF THE JONES' STEP PROCESS FOR METALLIZING LOW GRADE IRON ORES.



The Brunkner roasters themselves, around which centers the entire success or failure of the proposition, are of a type so commonly made use of in the ore dressing operations of non-ferrous metals. Each one is 18′ 6″ long and 8′ 8″ in internal diameter. They will require 12 H. P. to start and but 5 H. P. when in operation. It is expected that each one will hold fifteen tons of ore at a charge, and it is hoped that but four hours will be required for the metallizing operation; two of which will be consumed in heating up and two in the reduction or metallization. By having them placed in series of two and by having the waste gases from one pass into the other, it is expected that from the two roasters a charge of fifteen tons of ore will be available every two hours. The roasters themselves are equipped with oil burners for the purpose of giving the supplementary initial heat. Charges of coal will be put into the roasters at the proper time for the purpose of completing the reduction of the ore. The roasters have a 9-inch lining of fire brick and at definite portions throughout the inside shell of the roaster there are placed fire brick projections which will serve as lifters for the purpose, if possible, of getting the coal underneath the ore in order that the escape of the volatile gases may have an opportunity to come into as close contact with the ore as possible. The tube itself will revolve at varying speeds depending upon conditions. It has a variance of from one revolution in forty minutes to ten revolutions per minute.

The entire metallizing and concentrating plant is electrically driven throughout. For this reason it has the following motors installed:

1 75 H. P. A. C. induction motor. This for the No. 6 and No. 4 crushers, all the elevators in the crushing plant, and in fact everything up to the Avery scale.

1 20 H. P. Variable speed reversible Western Electric motor. This for one tube and for ore elevator to Avery scale.

1 20 H. P. Variable speed reversible Western Electric motor. This for one tube and for driving the ore charging larry.

1 20 H. P. Variable speed reversible Western Electric motor. This for drier and for the coal-charging larry.

1 5 H. P. A. C. induction motor. This for coal hoist.

1 40 H. P. A. C. induction motor. This for separating plant.

1 6 H. P. D. C. generator. This to be driven by the 40 H. P. motor for the purpose of generating D. C. for the magnetic separators.

1 5 H. P. A. C. induction motor. This for a No. 2½ centrifugal pump.

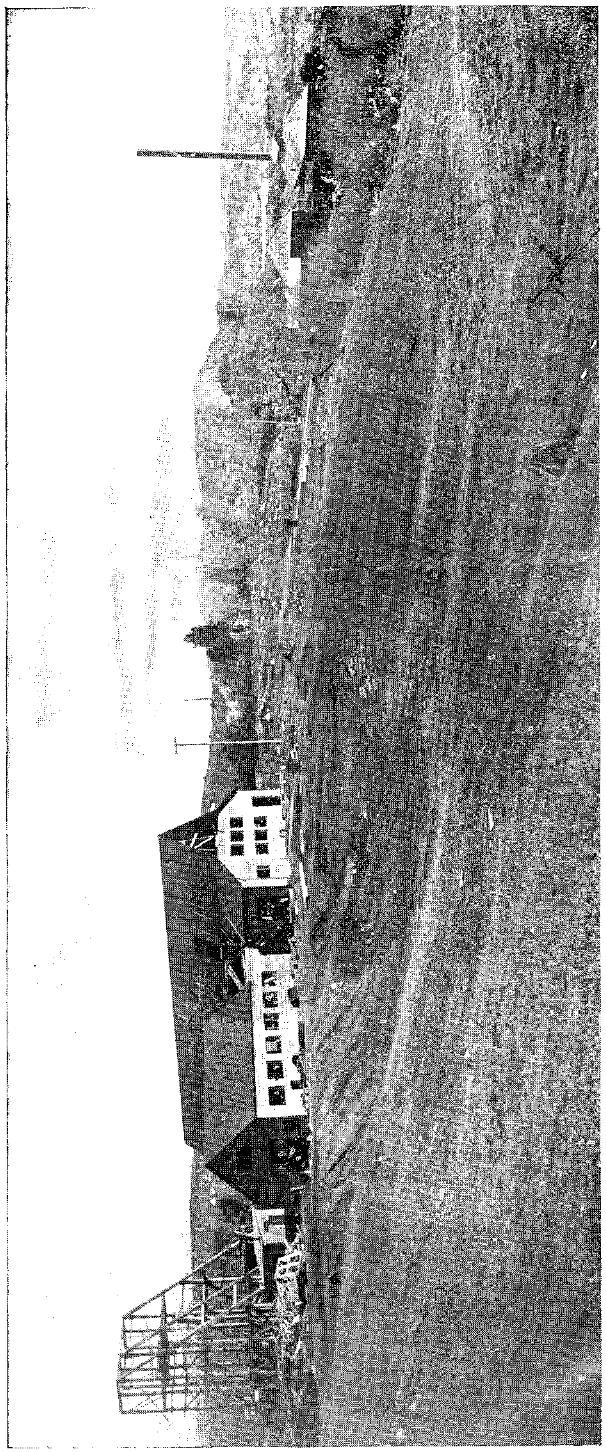
To carry out the housing of this experiment it has been necessary to erect a set of completely new buildings. These are altogether of the reenforced concrete type. Three large buildings have been constructed, one of which is known as the Generator Building, another as the Boiler House and Machine Shop Building, and the third as the Mill. The first of these, or the Generator Building, is 40 feet long and 30 feet wide. It consists of but one story and is 11 feet high. In it is 1-200 H. P. Corliss Engine and 1-150 K. W. Western Electric A. C. Generator, furnishing 440 volts. This generator is equipped with an excitor, switch board, rheostat, and the other paraphernalia which go to make up an electric station.

The Boiler House and Machine Shop is all under one roof, in a building 125 feet long, 18 feet wide and 8 feet high. The Boiler House proper is 40 feet long and 18 feet wide; and the Machine Shop, containing as it does the air-compressors and hoists, is 60 feet long and 18 feet wide. The Boiler House contains 1-250 H. P. Continental water tube boiler. There is also 1-15 H. P. upright boiler and 1 exhaust water heater. In the Machine Shop section of the house is found one ten drill Ingersoll-Sargeant Compressor, one four drill compressor of the same type, one Webster-Camp & Lane five foot drum 2nd motion hoist, one 20 inch lathe, one drill press, and one shaper.

The Boiler and Generator Houses are placed at a distance of about 400 feet from the Mill. The Mill is directly at the head of the shaft. This arrangement will be noted from an examination of the accompanying photograph. The general arrangement of the layout in the Mill can also be noted from an examination of the flow sheet of the process found in this chapter.

At the present time there is a great difference of opinion as to just what the cost of making iron from metallized ore will be. If it is possible to get a product containing approximately 95% of iron, and from 4% to 5% of gangue with but about .05% sulphur there will be no question but what this product could be successfully used in an open-hearth furnace. It is true that there might be some objection to its use there on the claim of its fineness, but because of the general nature of the Kloman ore it will probably be true that such an objection will not hold.

The main trouble will probably be with its quality. It will probably be certain that it will be impossible to obtain a product containing more than 85% of iron, and such a product, because of the high percentage of gangue necessarily present, would find no



PLANT OF KLOMAN MINING COMPANY AT REPUBLIC, MICHIGAN.

ready sale for open-hearth use. There is another great objection, which as yet has not been emphasized, and that is the tendency which this material possesses to absorb sulphur from the surrounding coal with which it is in contact. It will very probably be true that a final product will be secured from the metallizing plant containing not less than from .1% to .2% sulphur. For this particular reason it will probably be true that the natural outlet for the use of this material will be in a blast furnace. For that reason the fears of so many people that the installation of the Jones process for the utilization of the low grade iron ores will completely revolutionize the present practice of making steel is nothing more nor less than a visionary bubble.

ESTIMATE OF COST OF METALLIZING AND SMELTING LOW GRADE KLOMAN IRON ORE.

Mining	2.66 tons at $0.30	$0.798
Crushing	2.66 tons at .08	.213
Screening	2.66 tons at .05	.130
Concentrating	2.66 tons at .08	.213
Conveying	2.66 tons at .10	.266
Jigging	2.66 tons at .05	.133
Fuel		3.180
Repairs	2.66 tons at .10	.266
Tailing disposal	1.66 tons at .08	.133
Freight	1.00 ton at 1.50	1.500
Total cost at Chicago		$6.832
Cost per unit at Chicago		.08

SMELTING.

Ore	1.18 tons at $6.83	$8.06
Stone	.50 tons at 1.00	.50
Coke	1000 lbs. at 4.50	2.25
Labor and repairs		1.25
Cost per ton of pig iron at Chicago		$12.06

ANALYSIS.

	Crude ore per cent.	Concentrates per cent.
Iron	40	85
Silica	35	12.5
Other gangue	7	2.5
Moisture	1	

In arriving at this estimate the natural ore is credited with containing but 1% of moisture and 42% of gangue of which 35% is silica. As we lose 20% of the iron present in our process of magnetic concentration it becomes true that it will be necessary to use 2.66 tons of crude ore in order to get a concentrate containing 85% of iron.

It has been the endeavor to make the crushing, screening, concentrating, conveying, jigging, and repair costs full high and there is little doubt in the writer's mind but what the actual operating costs of certain of these items will be materially reduced when operating on a large scale.

The smelting center adopted has been Chicago. The cost of the metallized ore at this point will prove to be approximately $.08 a unit. It will roughly require ½ a ton of limestone to do the necessary fluxing. The amount of coke that would be required to smelt this product is at present a matter of mere guess work. Allowing .8 of a ton of coke for a ton of silica as our basis for the amount of coke required to flux out the silica and 300 pounds of coke for a ton of metal as our basis for melting the metallic iron present in the product it will be noted that but approximately 500 pounds of coke are required per ton of pig iron. 1,000 pounds have been allowed and the doubling of the requirement seems more than ample.

Adding up all of the various items it can be observed that it will cost approximately $12.00 to make a ton of pig iron out of many of Michigan's vast number of low grade iron ore deposits. It is believed that this figure allows ample allowance for any contingencies that may come up. It does not take into account the fact that there is a possibility of making a soluble coke as a by-product. It does not take into account the fact that there is a possibility that a product of high enough grade for open hearth use may be made. It has put, colloquially speaking, the worst foot forward and the figures show that it is a proposition worth developing.

We will all watch with great interest the growth of the ideas which Mr. J. T. Jones has clung to so tenaciously the past few years and we sincerely trust that within the next six months he will be able to break down the present bars of skepticism by having at hand actual proof concerning what can be done with regard to the metallization of certain types of Michigan's low grade iron ores.

MICHIGAN COAL.[1]

BY R. A. SMITH.

CONTENTS.

CHAPTER I.

OCCURRENCE AND EXTENT OF COAL AREAS.

Occurrence. Coal occurs in beds associated with shale, fire clay, black band ore, limestone, and to a less extent with sandstone. The latter more often increase in abundance at the expense of the coal. This is a most significant fact. The coal may be in a single bed or in several, separated by beds of shale or so-called slate, fire clay, etc. These laminae of shale may be no wider than a knife blade or may be many feet thick. Often thin veins of shale interbedded with the coals may thicken so that a single vein of coal becomes several distinct beds.

[1]Mainly an abstract of A. C. Lane's treatise in Vol. VIII, 1902, Michigan Geological Survey, with addition of statistical and other data.

The upper coals of Michigan are very apt to show this phenomenon. This makes it very hard to correlate them because corresponding veins vary in level more or less with the thickening and thinning of the shale laminae. Sometimes these, though often very persistent even when thin and knife-like, disappear and several beds, distinctly separated at one place, become a single thick one at another. In other cases, the content of clayey matter increases graduall̃y so that a coal vein grades vertically and laterally through cannel coal, bone coal to black shale. It is these shales with their gradation phases which many drillers confuse with true coal and thus are led to report great thicknesses of coal where little or even none exists. The shales, usually black, form in most cases, the roof of the coal seams. Shale forms an impervious roof, but is likely to be weak, and thus need a good deal of timbering, if close to the rock surface. An impervious roof is all important in Michigan as water is so abundant. At best, Michigan coal mines are much wetter than those of Ohio and Indiana, but the water comes chiefly from the coal—the foot wall. The cost of getting rid of the water is one of the chief factors that permits Ohio operators, in dull times, to lay down at a small profit their excess coal at the very tipples of Michigan mines at prices ruinous to Michigan operators. A sandstone roof is a very wet roof as in the case of the Gage No. 3 and no mine is known to have a real limestone roof. The Verne coals, however, are apt to have considerable limestone associated with them.

Extent. Coal beds in most districts are usually continuous for considerable distances and the existence of a coal bed can be predicted with some degree of certainty for some distance from known occurrences as in Pennsylvania and Ohio. *In Michigan, such conditions do not obtain. The beds thicken and thin, divide or unite, and pinch out so rapidly, or are cut out by sandstone beds or by erosion so often, that the finding of a thick bed at one place forms no proof that the same bed or other beds may be found a few hundred feet away. On the other hand, the absence of coal at a particular spot does not preclude the possibility of finding workable coal at astonishingly short distances away.* At the Corunna Mine, a 4 ft. vein of coal was found and 200 feet away not a trace was discovered, the bed having been cut out by sandstone layers. This variation in thickness, extent, and number of veins demands more complete prospecting to determine the extent and value of a coal bed after having found it, than it would, were the beds more continuous and more uniform in thickness and character.

The explanation of the great variation in the Michigan deposits in contrast to those of Pennsylvania and other coal states, lies in the difference in the relative conditions under which the coals of the two areas were formed. After the Maxville limestone was laid down in the more or less inclosed Michigan sea, the region was elevated above water bringing the Maxville within the reach of the erosive agents which cut it up into a network of river valleys. The Maxville on the southeast was wholly removed from Jackson nearly to Tuscola Co., the coal measures lying directly on the Marshall. In late Maxville time, the topography on the eastern side of the basin may have somewhat resembled that of eastern Kentucky. When the region was depressed these valleys became bays, lagoons, and estuaries possibly resembling the conditions of a drowned coast. It was in these depressions that vegetable material collected. Near Jackson, the Maxville forms the hills with the coal measures lying in between and flanking them. The Jackson trough was hardly more than 150 yds. wide and a few hundred feet long. From this it may readily be seen that in the southern and eastern parts of the basin, expecially, few if any of the coal veins could be continuous for any great distance.

CHAPTER II.

THE MICHIGAN COAL BASIN.

The Michigan coal basin, or the northern region of the Interior Basin, as it is now called, is the only one that lies in the Great Lakes drainage area. It comprises some 11,500 square miles and occupies almost the exact geographical centre of the Lower Peninsula. It is most ideally located, being in the heart of a thickly populated and rapidly growing manufacturing district. Not only this, but numerous railroads, Saginaw Bay and River, which penetrate to the very heart of the field, and the system of Great Lakes offer a means of distribution unequaled anywhere. Indeed, it is largely due to the rapid growth of manufacturing cities along the lower Great Lakes and the easy access to their markets that Michigan, with thin and variable veins of low grade coal and wet mines, owed the sudden and wonderful development of her coal industry between 1897 and 1908. No where in the history of the coal industry of the United States is there a like parallel in growth, unless we except the recent one of the Triassic basins of Virginia.

The Coal Basin may be roughly outlined by drawing line (See Fig. 12) from Jackson, to the northeast of Bellevue, Eaton Co., through Lake Odessa, Ionia Co., Lowell and Rockford, Kent Co., Newaygo and Woodville, Newaygo Co., Big Rapids, Mecosta Co., Evart, Osceola Co., Temple, Clare Co., Beaver Lake and West Branch, Ogemaw Co., Omer, Arenac Co., along the south side of the lower course of Rifle River, across Saginaw Bay to the north and east of Sebewaing, Huron Co., through Caro, Tuscola Co., Belsay, Genesee Co., through the northwest corner of Oakland county, to Lakeland, Livingston county, thence to Chelsea, Washtenaw county, and through Grass Lake back to Jackson. Some of the places, as Bellevue, Lowell, Big Rapids and Caro are just outside of the limits of the coal basin, while Newaygo, West Branch, Sebewaing, and Jackson are just inside. The outline so drawn does not represent the irregularities or the outliers of the borders. The data, except in certain localities on the eastern side, is too meagre to attempt anything more than an approximate representation of the outline of field. Coal formation undoubtedly exists outside of the area enclosed above and is lacking in other places inside.

Naturally the border of the coal basin is not so regular as is indicated on the map, but is more or less continuous, depending in a great measure upon the amount of erosion after the beds were laid down. It must be kept in mind that the coal measures were elevated above water and, have been exposed to erosive agents

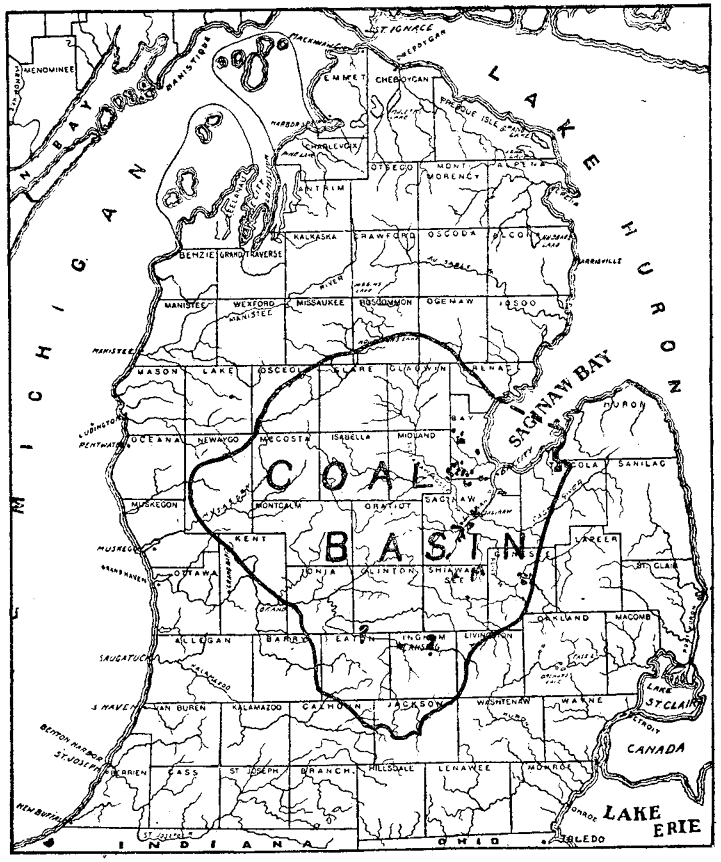


Fig. 12. Map of the Michigan Coal Basin. Portions colored black represent the areas of proven coal of commercial importance.

for an enormous length of time. Streams cut deep valleys in them and then the ice invasion planed and more or less leveled off these irregularities. Many of the valleys were grooved deeper while others were filled up by glacial debris. One of the results of the successive glaciations was the covering up of the rock surface by glacial material varying from a thin screen of almost nothing to a blanket 600 or more feet thick. It is this blanket that makes the line of demarkation between the various formations most uncertain in many instances. Where the screen is thin, the bed rock is exposed in places as along streams, etc., or wells penetrate it. Drillings for coal, brines, oil and gas, and water in Saginaw Valley, especially, have given a wealth of information. Thus the eastern and southeastern border of the basin is fairly well determined from the numerous well records and outcrops, but, on the western, northwestern and northern borders, the drift is so deep that outcrops do not occur and wells rarely reach bed rock. Here the border can only be guessed at from the few and perfect records of wells that reach bed-rock, from the occurrence of coal in the drift, or from inferred field relations with other formations.

The area outlined on the map occupies almost the exact geographical and the commercial center of the State. Commonly known as the Coal Basin it is the only formation in Michigan in which the beds do not dip toward and occur deeper at the center than at the margin. (See Fig. No. 12.) Apparently all other formations are true basins though shallow. The fact that the coal formations were laid down in a dissected or much cut up region probably has considerable bearing on the explanation.

At the base of the coal measures lies the Parma sandstone. Though not always present or recognizable, at some distance beneath this formation comes a sandstone, the Napoleon or Upper Marshall, which can be followed by outcrops or by well drillings, all the way from the sandstone bluffs of Huron county into Sanilac county and southwest past Island Lake into Hillsdale county, and thence in wells on to Grand Haven, Muskegon, and Ludington. Since it is full of water, it has been tapped many times for fresh water near its margin, and for salt and bromine waters toward the center. Such wells make it recognizable also at Tawas and to the northwest, thus for nearly two-thirds of the basin it has been followed fairly continuously.

The outcrop, or what would be an outcrop, were the glacial deposits stripped off, would be usually higher then the coal basin itself, thus it really makes a rim about the latter.* Below the Napoleon or outside it, no coal in commercial quantity has been or is ever likely to be found.

Many instances have occurred in Michigan where men have spent their time and money drilling for coal outside the coal basin.

* Lane, Vol. VIII, pt. II, p. 26.

Often, the Devonian black shales have led drillers on a proverbial wild goose chase as far as the find of coal is concerned.

Early geologists supposed the coal beds of Michigan and Ohio to have been originally continuous and were then folded gently so that erosive agents removed the coal from the arches. Were this so, one could expect to find outliers of coal which had escaped destruction. The[2] evidence is almost absolutely conclusive that these fields were never connected, thus exploration outside the coal basin in the hope of finding an outlier of coal is bound to be fruitless.

Thickness of Coal Measures. As noted on previous pages, the dip of the coal formations does not conform to the lower formations. The term basin referring to shape does not mean so much, when applied to the Coal Measures as when applied to the underlying formations. The Upper Marshall sandstone has been tapped at various places within the basin at depths varying from a few hundred to more than 1,200 ft. The Michigan series lies just above, except where eroded, so that, calculating from the average thickness of this series, the Coal Measures should come at a 1,000 feet or more in the deepest drillings. On the contrary, nothing like the Coal Measures proper has ever been found much deeper than 800 ft.

Evidently the strata of the latter are more nearly horizontal than the Marshall and other underlying formations, which must have been slightly depressed in the centre before the coal formation was laid down. Near the margin, the coal formation becomes very thin from erosion, but near the centre there are known local thicknesses of more than 600 feet. Thus, whatever unfavorable factors may affect coal mining in Michigan, excessive depth probably will never be one of them.

Since the coal formation was laid down on the much eroded surface of the Maxville limestone, it is natural that we find the coal lying *"In the minor undulations, independent of the general curve of the whole formation and the basin which it forms."* These undulations are called by miners "hills" or "rises" and "valleys" or "swamps." The term "pockety" is applied to such occurrences. It is a practical rule of miners that the coal rises and falls in undulations.

In the lower part of the undulations, the coal is thicker and thins to the rise. Nearly every mine presents an almost invariable series of such occurrences. (See Sebewaing cross section, Fig. 3, Lane, Vol. VIII, pt. 2, p. 31.) This tends to make the deposits

[2]See Lane Vol. VIII, pt. II, p. 27.

trough shaped. The latter phenomena are also common to other coal fields as noted by Bain & Keyes of Iowa and Orton of Ohio.

The lower and thicker parts of the troughs of coal are very apt to be capped by a smaller coal seam known as a rider. Dr. A. C. Lane noted this phenomenon in Michigan coal troughs but was not sure of its wide application to Michigan deposits. Later studies by him and Mr. W. F. Cooper[3] seem to warrant a much more general application of the principle. In Bay county, riders seem to be almost universal. Sometimes these riders are locally thick enough to mine, but, they would require even more careful exploration than the coal troughs to determine their economic value.

Bain especially developed the law of coal riders. His explanation was that the lower coal, which, if 5 ft. thick, represents 50 to 60 ft. or more of peaty material, in settling and compacting made a shallow basin above in which the rider formed. Thus riders are not considered unfavorable signs for more coal below.

Dr. Lane divided the coal horizons into seven and Cooper in Bay county report added seven more, making fourteen in all. The full series are: Reese Coal? Unionville? Salzburg? Rider, Salzburg Coal, Upper Rider, Upper Verne, Lower Verne Rider, Lower Verne Coal, Middle Rider, Saginaw Coal, Lower Rider, Lower Coal, Bangor Coal, and Bangor Rider. Since the whole formation varies so rapidly in the thickness and nature of its beds, probably some horizons may be synonymous. All of the beds occur within a vertical distance of 400 feet and, since a seam may vary 20 ft. or more in elevation in a couple of hundred feet, and also vary greatly in thickness, little value should be placed on such a series of horizons. Doubtless ten or twelve of the above are distinct horizons.

The Bangor Coal and Rider form the lowermost veins, the mother seam being from 350 to nearly 400 feet below surface in Bay county. The rider is often 50 to 60 ft. above. Dr. Lane thinks that these coals may be equivalent in part to his Lower Coals, the next horizons above. Not much is known of them but, from some of the deeper drill holes, the Bangor Coal appears to be of sufficient thickness for working, especially if it can be mined with the underlying fire clay. The roof is black shale.

The Lower Coal and Rider come next in order above and usually appear in the horizon lying between 240 and 325 ft. The mother seam has an observed maximum thickness of three feet. The usual foot and roof shales are apparently quite variable in thickness. This seam appears to be of probable commercial value.

[3]Bay County Report 1905, p. 190.

The Saginaw Coal, one of the thickest and most extensive seams in the state, is probably the best vein in quality, though its coal is non-coking. Its thickness is often more than 3 feet and it forms the base of most of the mining in Saginaw county. The superior St. Charles coals come from this horizon. The Middle or Saginaw Rider also seems to be a seam of considerable thickness and possibly the East Saginaw mines have their shafts in this coal.

The Lower Verne is at some places so closely associated with the Upper Verne that the two could be worked as one seam. In other places they are 40 feet or more apart. This vein is of much lower grade than the Upper, for it has much ash and sulphur. The roof is usually none too good. The general average in thickness for the coal areas is somewhat near two feet and it would be the base of more extensive mining operations, were the coal of better grade.

The Upper Verne stands in the same relation to Bay county mining as the Saginaw Coal does to Saginaw county. Thicknesses above three and four feet are often found. As noted above, it is of much better grade than the Lower Verne, being much freer from ash and sulphur. It has another good quality in not having a high water content like the Saginaw. The fixed carbon is rather low, (see table of analyses, Chap. III) and the volatile matter high. This coal leans toward the coking and gas making coals, but trouble in handling or adapting it to the producers in use, and the rather poor quality of the coke have prevented any use of the coal for such purposes. According to analyses the Verne coals appear to be related to the lignite coals. Probably they were never subjected to deep burial, so still resemble the woody end of the coal family.

As so-called fire clay is a common foot wall, it may, in the future, give added value to the seams, so that the thinner ones can be profitably worked. Plans for using the fire clay and shale of an abandoned mine in Bay county are reported as already under way. The usual black shales form the roof.

The Upper Rider is often associated with the mother seam. It's thickness of 12-20 inches warrants the supposition that locally it may be workable. "Washouts" often cut out this coal, and the roof is apt to be thin, weak, or wet, so care must be taken in proving up before beginning mining operations.

The Salzburg Coal and its rider are very often removed by erosion. It is only locally that the bed-rock surface is high enough to contain these horizons. As the thickness of the mother seam is more than two feet, and in some cases over three it has possibilities for profitable mining but the nearness to the rock surface makes in general unfavorable mining conditions.

The Reese and Unionville coal seams are little represented in drillings. Lying so high in the coal measures, erosion would have removed them in large part if they really ever existed.

Variation in Michigan Coal Measures. Without question, no bed of coal was ever continuous over the basin. Records at Alma, St. Louis, St. Johns, Ithaca show little or no coal. These, however, do not form conclusive evidence of the non-continuous character of the beds, as we know sandstone beds often replace the beds, showing that the coal was cut out after it was formed. A more significant fact lies in the occurrence of beds at all sorts of elevations above the Napoleon from 163 to 1,005 feet as at Sebewaing and Midland respectively. Deep wells near the center of the basin show black shales and bituminous limestones at the same horizons at which coal occurs at the margins. The beds are often of such local extent that it is never safe to attempt any exploitation of coal deposits without a proving of the area by thorough drilling, and even this is not always reliable. Too often a coal bed gives way to black shale horizontally and vertically or its place may be taken by sandstone. Cannel coal and bone coal are often observed as gradations from coal to black shale. The never ending alternation of sandstone and shale exists in every variety and the existence of coal even in the midst of a productive area cannot be predicted with any degree of certainty. Iowa as well as other coal fields seem to have similar, though not so extreme conditions of variation.

Areas Favorable for Coal Occurrence. A greater abundance of coal is found nearer the margin of the main coal basin, the coal beds diverging and thinning out with (increasing) depth and the coming in of the lower coals. The rest of the series thickens toward the center but, in other directions, irregular and sudden thinning is often the rule.

Jackson and Sebewaing are at the every edge of the basin. Though Williamston, Saginaw and Corunna are nearer the center, the basal sandstones are but little over 400 ft. below surface, so that they are not in the deeper parts of the basin.

A greater abundance of coal nearer the margin is to be expected. The areas most favorable for the growth of vegetable material is along the coasts, in lagoons, etc. Obviously, the region toward the center of the basin was more likely to be open sea and could hardly have other deposits than muds and sands. One must remember

that the land surface upon which the coal deposits were laid down was considerably cut up by erosion.

Dr. Lane thinks that the southeastern part of the basin may have been not unlike a drowned coast with all the attendant features of lagoon, estuary, drowned valley, etc. Around Jackson, the evidence points to such a conclusion for the Maxville limestone tops the hills, between which, and flanking them, lie the coal measures. The extreme "pockety" nature of the coal deposits around Owosso and Corunna seem to be even more suggestive of such conditions.