With the Authors' Compliments.

MINING INDUSTRIES.

JAMES D. HAGUE.

[Extract from the Official Classification.]

CLASS 43.—MINING AND METALLURGY.

Collections and specimens of rocks, minerals, ores. Ornamental stones. Hard stones. Refractory substances. Earths and clays. Various mineral products. Raw sulphur. Rock salt; salt from salt springs.

Mineral fuel: various kinds of coal, coal dust, and compressed coal. Asphalt and rock asphalt. Bitumen. Mineral tar. Petroleum, etc.

Metals in a crude state: pig-iron, iron, steel, cast-steel, copper, lead, silver, zinc, etc. Alloys.

Products of washing and refining precious metals, of gold-beating, etc.

* * * * * * *

[NOTE.—The following report refers to only a portion of the subjects in the class.]

[In forwarding this report to the Department of State, Mr. Hague offered an explanation, under the date of December 26, 1879, from which the following is extracted:]

"When I had the honor of accepting, nearly two years ago, the appointment of Additional Commissioner to the Paris Exposition of 1878, I confidently expected to have fully discharged, long before now and to the best of my ability, all the obligations incurred by such acceptance.

"Among these obligations, as I found after arrival in Paris, was the preparation of a report upon Group V of the Exposition. A brief inspection of the catalogue, however, showed this group to be so comprehensive in its range, comprising exhibits of products so diverse in character, that, after consultation with the Commissioner-General, I determined to limit my official investigation to some of the exhibits of Class 43, embracing ores, minerals, and the crude products of mining industry.

"It was my good fortune to secure the aid of my friend, Mr. George F. Becker, of the United States Geological Survey, and lately of the University of California, in making the necessary examination at the Exposition, and he has contributed largely to the paper which I herewith submit."

The larger portion of the accompanying report is the work of Mr. George F. Becker. The authorship of each of the several papers is shown by the following statement:

France and the French Colonies, by J. D. Hague & G. F. Becker.
Great Britain, by .... G. F. Becker.
Austria, by .... " "
Russia, by .... J. D. Hague.
Sweden, by .... G. F. Becker.
Norway, by .... " "
Belgium, by .... J. D. Hague & G. F. Becker.
Austria-Hungary, by .... G. F. Becker.
Italy, by .... " "
Spain, by .... " "
Portugal, by .... " "
Greece, by .... " "
Dutch East Indies, by .... " "
Bullion Product of the United States, by .... Dr. A. Soetbeer;
translated by .... Mrs. G. F. Becker.

The aim of the report is to present a sketch or a review of the condition, during recent years, of the chief mineral industries of the principal foreign countries represented at the Exposition, utilizing for this purpose much of the varied information which, for the occasion of the Exposition, had been made available, in printed form or otherwise, either by foreign Governments or private exhibitors.

JAMES D. HAGUE.

PRINCIPAL ERRATA.

Page 169, 6th line from top, for "1866–1877" read 1866–1875.
" 170, 4th " " " " "Laurim" " Laurium.
" 182, 1st " of table, " "48,962" " 48,662.
" 183, 5th " from top, " "apparatuses" " apparatus.
" 185, 1st " " " " "has" " was.
" 187, 19th " "bottom " "composed" " exhibited.
" 187, 10th " " " omit "above ground."
" 187, 1st " " " " "wires" read lines.
" 192, 17th " " " " "59.09" " 59.00.
" 198, 8th " " top, " "work" " week.
" 203, 22d " " " " "art" " wet.
" 206, 12th " "bottom " "surbars" " Swede bars.
" 207, 8th " " " " "260,750" " 269,750.
" 216, price of silver for 1870, for "$69\frac{9}{16}$" " $60\frac{9}{16}$.
" 225, Russia, 1865, for "465,988" " 465,989.
" 230, 13th line from top, for "habitus" " habital.
" 233, 1st " "bottom, " "Zukumft" " Zukunft.
" 234, Victoria, prior to 1870, for "£152,524,818" " £152,624,818
" 241, 18th line from bottom, for "numerous" " enormous
" 251, 19th " " top, " "iridosonine" " iridosmine.
" 270, 3d " " bottom, " "Has Sachsen" " Hus Sachsen
" 271, 7th " " top, " "resilverized" " desilverized.
" 301, 1st " " " " "Kilos" " Kilometers.
" 301, 1st " " bottom, " "carved" " earned.
" 307, 16th " " top, " "Ligmien" " Ligurien.
" 315, 6th " " " aggregate horsepower,
for "659" " 668.
" 322, 14th " " " " "curioseuse" " cuivreuse.
" 322, 23d " " bottom, " "Breja" " Beja.
" 326, 20th " " " " "received" " stripped.
" 341, 3d " " " " "worked" " washed.
" 353, 2d table total in 1877, " "998,421,754" " 98,421,754.
" 361, 5th line from bottom, after "weight" insert presents.

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MINING INDUSTRIES.

I.

RANK OF THE GREAT MINING COUNTRIES.

PRODUCTION AND RANK OF THE GREAT MINING COUNTRIES OF THE WORLD, 1876.

Relative rank of the great mining countries of the world, 1876.

In the Belgian exhibit at Paris was displayed an interesting chart showing the total quantities of coal and base metals produced in the principal countries of the world, the quantities per square kilometer, and the rank occupied by each for the year 1876. Such a general statement seems desirable as an introduction to the following papers, and the figures used in plotting the chart have been employed for that purpose.

Units; *tonne* of 2,205 pounds.

In the original, *tonnes* of 1,000 kilos, or 2,205 pounds, and square kilometers are the units employed. The unit of weight is so near our own ton that its conversion seems unnecessary. The products per square kilometer have been reduced to yield per square mile by multiplying by 2.6. Gold and silver have also been added to the list from data obtained from Dr. A. Soetbeer's memoir, "*Edelmetall-production, Petermann's Mittheilungen, Ergaenzungs-Heft, No.* 57, 1879."

Square kilometers.

COAL.

Product of coal in various countries, and per square mile.

Countries.	Total product in 1876.	Countries.	Product per square mile.
	Tonnes.		*Tonnes.*
1. Great Britain	135, 477, 282	1. Belgium	1, 264
2. Prussia*	43, 451, 371	2. Great Britain	1, 118
3. United States	41, 000, 000	3. Prussia	325
4. France	17, 047, 762	4. Austria	101
5. Belgium	14, 329, 578	5. France	83
6. Austria	11, 867, 715	6. United States	10
7. Russia	1, 708, 512	7. Spain	2. 6
8. Spain	101, 522	8. Russia	0. 78
9. Sweden	96, 674	9. Sweden	0. 50

*Among the German states Prussia only is represented in the tables, because at the time when the figures were compiled the mineral statistics of the German Empire had not been published.

Relative product of various countries.

IRON ORE.

Iron ore.

Countries.	Total product in 1876.	Countries.	Product per square mile.
	Tonnes.		*Tonnes.*
1. Great Britain	17,111,049	1. Luxembourg	1,204
2. United States	4,500,000	2. Great Britain	140
3. France*	3,081,026	3. Belgium	23
4. Prussia	2,072,250	4. Prussia	15
5. Russia	1,935,187	5. France	15
6. Luxembourg	1,196,729	6. Austria	4.7
7. Sweden	787,092	7. Sweden	4.4
8. Austria	554,965	8. Spain	2.3
9. Spain	436,586	9. United States	1.3
10. Belgium	269,206	10. Russia	0.5

* Figures for 1872 (latest official statistics).

PIG-IRON.

Pig-iron.

1. Great Britain	6,642,895	1. Luxembourg	231
2. United States	2,093,236	2. Great Britain	55
3. France	1,449,537	3. Belgium	44
4. Prussia	1,324,338	4. Prussia	10
5. Belgium	490,498	5. France	7.8
6. Russia	427,548	6. Austria	2.3
7. Sweden	348,257	7. Sweden	2.1
8. Austria	273,045	8. United States	0.5
9. Luxembourg	280,500	9. Spain	0.3
10. Spain	56,462	10. Russia	0.2

BAR-IRON.

Bar-iron.

1. United States	1,922,000	1. Great Britain	15
2. Great Britain	1,822,704	2. Luxembourg	7.3
3. France	875,000	3. Prussia	6.0
4. Prussia	814,000	4. France	4.2
5. Belgium	399,000	5. Belgium	3.6
6. Russia	304,056	6. Sweden	1
7. Sweden	167,719	7. United States	0.5
8. Spain	41,464	8. Spain	0.2
9. Luxembourg	7,418	9. Russia	0.16
10. Austria*	....	10. Austria*	....

STEEL.

Steel.

1. Great Britain	545,560	1. Belgium	6.5
2. United States	525,996	2. Great Britain	4.4
3. France	254,191	3. United States	1.4
4. Prussia	126,500	4. France	1.3
5. Belgium	75,258	5. Sweden	1
6. Sweden	18,785	6. Prussia	0.94
7. Russia	3,945	7. Spain	0.16
8. Spain	2,720	8. Russia	0.018
9. Austria*	....	9. Austria*	....

* Not stated in the official statistics.

LEAD.*

Lead.

1. Spain	101,522	1. Belgium	0.614
2. Prussia	70,207	2. Spain	0.528
3. Great Britain	59,606	3. Prussia	0.523
4. United States	58,125	4. Great Britain	0.491
5. France†	21,339	5. France	0.104
6. Belgium	6,963	6. Austria	0.036
7. Austria	4,291	7. United States	0.016
8. Russia	1,083	8. Russia	0.0005

* In the absence of recent official statistics, Italy and Greece do not appear in this table, in spite of their importance as lead-producing countries. The former produces about 9,000, the latter about 8,000 tons.
† Figure for 1872 (latest official statistics), including the wrought metal.

Relative product of various countries.

ZINC.*

Countries.	Total product in 1876.	Countries.	Product per square mile.
	Tonnes,		*Tonnes.*
1. Prussia	83,634	1. Belgium	4.420
2. Belgium	49,960	2. Prussia	0.624
3. France	17,434	3. Great Britain	0.546
4. United States	16,091	4. Austria	0.338
5. Great Britain	6,747	5. Spain	0.156
6. Russia	3,990	6. France	0.078
7. Austria	3,979	7. United States	0.052
8. Spain	2,940	8. Russia	0.018

Zinc.

*According to non-official statements, crude metal.

GOLD.

[Average of the five years 1871 to 1875.]

Countries.	Total product.		Countries.	Product per square mile.
	Kilos.	*Dollars.*		*Dollars.*
1. Australia	59,900	39,812,000	1. Australia	13.29
2. United States	59,500	39,545,000	2. United States	13.07
3. Russia	33,380	22,184,000	3. Bolivia	2.66
4. New Grenada	3,500	2,326,200	4. Russia	2.65
5. Mexico	2,020	1,324,500	5. Mexico	1.76
6. Bolivia	2,000	1,329,264	6. New Grenada	0.80
7. Brazil	1,720	1,143,200	7. Brazil	0.36

Gold.

SILVER.

[Average of the five years 1871 to 1875.]

Countries.	Total product.		Countries.	Product per square mile.
	Kilos.	*Pounds troy.*		*Ounces troy.*
1. Mexico	601,800	1,612,400	1. Mexico	25.45
2. United States	564,800	1,513,200	2. Germany	22.04
3. Bolivia	222,500	596,140	3. Chili	19.95
4. Germany	143,080	383,350	4. Bolivia	14.31
5. Chili	82,200	220,240	5. United States	6.00
6. Peru	70,000	187,550	6. Austria-Hungary	5.16
7. Austria-Hungary	38,550	103,290	7. Peru	4.50
8. Russia	11,495	30,800	8. Russia	0.04

Silver.

II.

FRANCE.

FRANCE AND THE FRENCH COLONIES.

FRANCE.*

Gaulish mines, and knowledge of metals.

The mining industry of France is of ancient origin. Before the Roman conquest the Gauls were familiar with gold, silver, copper, tin, bronze, and iron. Under the Roman rule the exploitation of metalliferous mines gave rise to some very important and extensive works, which were abandoned, however, at the time of the Northern invasion, to be resumed again by the Saracens in the Pyrenees, the Alps, and some other districts; but it was only about the end of the eleventh century that the mines of France assumed any real importance. In the thirteenth century the mines were again abandoned, in consequence of the long-continued wars, which disturbed the country and dispersed the laborers. They were not reopened until the commencement of the sixteenth century, shortly after the discovery of America, when greater depths in the mines were made accessible by the opening of deep-drainage tunnels, and ores of low value were utilized by improved processes of crushing and separating the richer mineral from the worthless gangue. Operations were again arrested by the Thirty Years' War and incidental disturbances. In the eighteenth century, and particularly under Louis XVI, some prosperous mining operations were prosecuted in Brittany, the Pyrenees, and in Central France. The introduction of powder and of improved mechanical appliances increased the effect of labor, and resulted in the working of the mines at greater depths. But this prosperity was only temporary; the creation of a corps of mining engineers (1781) and of a school of mines (1783), and the law of April 1, 1810, which defined and assured the rights of ownership in mines, did not succeed in reviving the industry in metal mining of France, which (not considering iron) to-day employs only about 4,000 laborers, producing annually a value of only 6,356,607 fr.

Roman exploitation. The Saracens. Internecine broils of the middle ages. Improved methods. Period of Louis XVI. Introduction of gunpowder.

Few paying mines in France, except iron.

It is to be remarked that, excepting the ores of iron, few of the metalliferous deposits of France are sufficiently rich, and at the same time sufficiently accessible, to repay exploitation.

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* Mainly from the "*Statistique de l'Industrie Minérale*" and other official sources.

FRANCE.

Since the year 1791 there have been granted 1,233 mining concessions of every sort. Of these 615 were for combustible materials, 297 for ores of iron, 225 for metals other than iron, 96 for sundry substances. In 1872 there existed 611 concessions of mines of coal, anthracite, and lignite, covering a superficial area of little more than 5,418¼ square kilometers (about 2,092 square miles); 251 concessions of iron mines, with a superficial area of 1,187.69 square kilometers (about 458 square miles); and 222 concessions of mines of sundry metals—embracing an extent in area of 2,867.79 square kilometers (about 1,107 square miles). At the end of 1875 the number of concessions of mines in France had increased to 1,256, of which 613 were for coal or mineral fuel, 284 for iron, 244 for sundry metals, and 615 for various substances. Besides these there are a great number of quarries from which are obtained materials for construction, building-stones, marbles, clays, refractory earths, phosphates, ochers, talc, barytes, sulphur, rock-salt, alum, etc.

Mining concessions, In 1872. In 1875.

Ores of copper are rare in France. Such as are treated there metallurgically are brought from Bolivia, Algeria, and Italy; the supply of metal from these sources, and from the remelting of old stock, being supplemented by importations of copper from England, the United States, and Chili, especially the last-named country.

Copper ores.

In addition to the domestic supply of lead ores in France are those sent from Sardinia, Spain, and Algeria; while lead is imported in the pig from England, Spain, and Belgium.

Lead ores.

Ores of zinc are mined and treated to some extent in the south of France; the principal portion of the zinc ores treated in France, however, come from Spain, Germany, and Belgium. The crude metal is also brought from Silesia and other sources for manufacture.

Zinc ores.

The supplies of manganese, mercury, antimony, cobalt, tin, and the precious metals employed in the industries of France come almost altogether from foreign countries. Within recent years large quantities of nickel ores have been sent to France from New Caledonia, one of the French colonies of the South Pacific.

Manganese, mercury, antimony, tin, gold, silver, etc., imported.

The most important elements in the mining industries of France are iron and coal. The iron deposits have been worked since the time of the Gauls in many localities where the ore was found sufficiently rich to be reduced in small charcoal-hearths. This industry continued to increase steadily from the end of the sixteenth century, when it first assumed a real importance, until 1860, when the necessity of

Iron ore. Treaties of 1860.

FRANCE.

Importation of richer iron ores.

competing with foreign products, to which commercial treaties had opened the country, brought about the importation of richer ores from a distance and even from abroad, with which, by the use of coke, it was possible to produce iron comparable in quality to that made with charcoal at a higher cost.

Substitution of richer foreign ores for the poor native ores.

This change in the metallurgical industry, together with the gradual substitution of steel for iron, has diminished the production of iron ores of low tenor, which are of very abundant occurrence in France, by diverting the attention of metallurgists to the richer deposits of the Pyrenees and the Alps, where extensive and important operations have been undertaken. Notwithstanding this, the importance of foreign ores for treatment in France appears to have increased somewhat in spite of the loss of Alsace and Lorraine.

Importation and consumption of iron ores in France.

The following table shows the importation of iron ores into France, in juxtaposition with the consumption for a series of years. The French *tonne* is 1,000 kilos, or 2,205 lbs. avoirdupois.

Year.	Importation.	Consumption.
	Tonnes.	*Tonnes.*
1863	117,567	3,292,486
1872	438,734	3,105,402
1873	720,508	3,418,779
1874	801,249	3,104,534
1875	832,875	3,159,076

Sources of foreign iron ores.

The sources upon which France draws for iron ores may be seen from the following table:

Country.	1873.	1874.	1875.
Algeria	267,332	336,282	383,807
Spain	175,591	186,168	150,884
Belgium	120,932	92,934	132,373
Italy	123,081	145,076	129,211
Other countries	33,572	40,789	36,600
Total	720,508	801,249	832,875

Coal.

Early development of coal mining.

Coal was mined at Roche-la-Molière, in the valley of the Loire, as early as 1321. In the sixteenth century there were exploitations in coal at Brassac and at Grand'-Combe. At the end of the seventeenth century coal mining was developed at Decize, and French coals were sent to Paris in competition with English coal, which had been used there since 1520. During the eighteenth century the coal-mining industry of France assumed considerable importance. In 1720 the Vicomte Désandroins discovered coal at Fresnes, and in 1734 at Anzin. The first steam engine was brought

The first steam-engine for mine draining in France.

FRANCE.

Coal.

Compagnie des Mines d'Anzin.

to France in 1732, and employed in draining the mines of Anzin. At the present day the collieries of the *Compagnie des Mines d'Anzin* are the most important in France, their annual production being about 2,000,000 tonnes, or more than one-eighth of the entire product of the country. In 1789 the coal mines of sixteen provinces produced 240,000 tonnes, a quantity about equal to the coal importation of that time. Since then the production has increased 66-fold, while the importation has increased about 32-fold, the latter being now only about 48 per cent. of the native production, to which it was about equal in 1789, and only 33 per cent. of the total consumption, of which it then formed 53 per cent.

Increase of production: 1789–1875.

Importation, exportation, and consumption: 1873–1875.

The French importation, exportation, and consumption of coal for three years were as follows, in tonnes:

	Importation.	Exportation.	Consumption.
1873	8, 028, 660	694, 670	24, 702, 380
1874	7, 433, 470	747, 050	23, 417, 530
1875	8, 282, 220	671, 580	24, 657, 530

Sources of foreign coal.

More than one-half the coal imported comes from Belgium, about one-third from England, and an eighth from Germany. Of the exported coal nearly two-fifths goes to Italy.

The manner in which coal is consumed is always an interesting question from a technological point of view. The following are the data for France:

Mode of consumption of coal.

How consumed.	1873.	1874.	1875.	
	Tonnes.	*Tonnes.*	*Tonnes.*	*Per cent.*
Mines	1, 042, 230	1, 116, 960	1, 174, 290	} 24. 58
Smelting works	4, 969, 859	4, 699, 509	4, 886, 883	
Railways	2, 108, 471	2, 031, 119	1, 980, 773	8. 03
Ocean steamers	327, 700	281, 500	309, 500	1. 26
River steamers	71, 900	61, 800	68, 000	0. 27
In other ways (by difference)	16, 182, 220	15, 226, 642	16, 238, 084	65. 86
Total	24, 702, 380	23, 417, 530	24, 657, 530	100. 00

By reference to the articles on Great Britain and Austria it will be seen that the percentage consumption varies greatly in the three countries.

Mean price.

The mean price of coal and lignite has risen steadily during the period covered by the table. It was as follows:

	Francs.
In 1863	11. 31
In 1867	12. 23
In 1872	13. 46
In 1875	15. 93

These are practically prices of coal, to the production of which that of lignite bears a very small proportion.

FRANCE.

Products of mines.

Table of the products of the French mines.

Products of the mineral industry.	1863.	1867.	1872.	1875.
Combustible minerals:	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
Coal	10, 447, 022	12, 464, 659	15, 359, 195	16, 504, 635
Lignite	262, 547	274, 029	443, 319	452, 205
Total	10, 709, 569	12, 738, 688	15, 802, 514	16, 956, 840
Peat	421, 342	326, 744	324, 323	317, 748
Raw iron ore	4, 009, 624	3, 279, 395	3, 081, 026	2, 505, 870
Metallic ores:				
Copper	70, 870	75, 508	7, 653	8, 698
Lead	305	220	817	....
Lead and silver	106, 629	89, 809	77, 513	*8, 728
Antimony	36	100	173	223
Manganese	4, 239	4, 434	10, 315	9, 016
Nickel and cobalt	23	....	....	....
Zinc	....	550	202	4, 088
Tin	....	....	273	1, 000
Iron pyrites	28, 717	40, 933	45, 813	131, 154
Iron and copper pyrites	....	....	89, 539	....
Total	210, 819	211, 554	232, 298	162, 907
Various minerals:				
Bauxite and aluminous minerals	....	1, 200	1, 600	2, 669
Sulphur	....	....	4, 563	4, 900
Bitumen and bituminous schists	147, 377	163, 932	208, 130	140, 696
Graphite	10	....	1	....
Rock-salt	168, 364	212, 767	191, 722	231, 642
Total	315, 751	377, 899	406, 016	379, 907

*In former years the crude ore as it came from the mine was entered in the *Statistique*, but of late years the poor ore which is concentrated appears in the tables only for the weight of the concentration.

To complete the foregoing statement of the products of the mining industry there should be added the products of quarries, concerning which accurate statistical data are not readily obtainable. They furnish building materials, hard stones, marbles, jasper, agate, slates, clays, phosphates, etc., which in the aggregate form a very important part of the mineral resources of the country.

The following table will give a sufficient idea of the foreign trade in ores: Foreign trade in ores.

Names of minerals.	1873.		1874.		1875.	
	Importation.	Exportation.	Importation.	Exportation.	Importation.	Exportation.
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
Lead ores	12, 086	2, 512	12, 631	2, 848	12, 495	3, 595
Copper ores	4, 591	1, 058	7, 349	1, 256	6, 462	1, 746
Zinc ores	25, 370	3, 250	23, 720	1, 743	25, 219	2, 786
Tin ores	.....	.....	428	....	....	....
Manganese	24, 498	1, 651	26, 014	686	17, 440	1, 362
Antimony	29	1	27	96	37	134
Iron pyrites	14, 416	14, 697	11, 785	9, 893	25, 755	13, 770
Sulphur	47, 420	459	46, 293	114	38, 916	58
Graphite	975	51	934	73	973	55
Other ores	4, 298	449	4, 226	924	2, 675	40
	Kilos.	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*
Ores of gold and platinum	32	....	493	....	1, 910	....
Ores of silver	4, 546	....	123, 119	104, 259	121, 356	56, 259

FRANCE.

Statistics of laborers and wages.

In 1872 the laboring population employed in the mining industry amounted to about 320,000 men, of which number 134,173 were employed in the mines and peat works, 19,820 in underground quarries, 78,319 in open quarries, and 86,503 in metallurgical establishments. The following table presents some interesting data concerning wages and value of the products of labor in mines of different nature:

	Mines of—	1863.	1872.
Mean of wages paid annually to laborers in mines of	Mineral fuel	$152 40	$196 00
	Peat	14 40	13 00
	Iron	111 50	149 40
	Other metals	113 40	117 40
Value annually produced per laborer in mines of	Mineral fuel	329 00	478 00
	Peat	25 60	26 60
	Iron	241 00	304 00
	Other metals	253 00	256 00
		Tonnes.	*Tonnes.*
Average annual production in tonnes of material per laborer in mines of	Mineral fuel	146. 50	172. 50
	Peat	13. 80	12. 05
	Iron	275. 00	320. 00
	Manganese	34. 90	23. 60
	Iron pyrites	108. 00	136. 00
	Copper pyrites	....	162. 50
	Argentiferous galena	31. 08	34. 06

In the above table the franc is reckoned at 20 cents United States currency. The tonne is 1,000 kilos=2,205 pounds.

FRANCE.

Number, extent, and equipment of mines: 1863–1872.

A general idea of the condition of the mining industry of France is expressed by the following tabular statement, showing the number, extent, and equipments of mines in the years named below:

Mines of—			1863.	1872.
Mineral fuel	Number of mines		322	310
	Greatest depth ... feet		2, 066	2, 093
	Steam-engines	Number	750	873
		Horse-power	28, 979	40, 824
	Laborers employed		73, 357	91, 899
	Total production ... tonnes		10, 709, 658	15, 802, 514
Peåt	Number of exploitations		1, 655	......
	Laborers employed		30, 518	26, 893
	Total production ... tonnes		421, 342	324, 697
Iron	Number of mines		92	81
	Number of quarries		814	282
	Steam-engines	Number	53	47
		Horse-power	787	755
	Laborers employed		14, 545	9, 605
	Total production ... tonnes		3, 277, 895	2, 781, 790
Other metals	Number of mines		59	51
	Greatest depth ... feet		....	804
	Laborers employed		4, 572	4, 029
	Total production ... tonnes		210, 819	232, 296
Bituminous schists, bitumen, and sulphur.	Number of mines		25	26
	Laborers employed		....	714
	Total production ... tonnes		147, 387	214, 293
Rock-salt	Number of mines		13	16
	Greatest depth ... feet		571	869
	Steam-engines	Number	32	35
		Horse-power	338	492
	Hydraulic engines	Number	3	13
		Horse-power	14	147
	Laborers employed		999	1, 033
	Total production ... tonnes		168, 364	191, 720

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It is not practicable to bring these tables up to date, for the form in which the statistics are published has been slightly changed; nor is this altogether to be regretted, since the data are evidently, if accurate, very incomplete.

Incompleteness of the data.

Laborers working in the peat-bogs, for example, certainly do not work the whole year through for thirteen dollars, and, if not, the corresponding data as to the number employed give no idea as to the amount of work done.

Fluctuations in wages and production per man.

The price of labor has risen since 1872. In 1875 the mean wages paid colliers was $211.65. The production per man in the coal pits has notwithstanding diminished. In 1875 it was 156 tonnes, against, 172.5 in 1872. This falling off is possibly due to the increased depth of the mines, but the difference is very large to be accounted for in this way.

Number and power of steam-engines in French mines: 1875.

Engineers will be able to gauge the extent of the mining industries of France in 1875 by a glance at the following table of the number and power of the steam-engines in use in that year:

Character of the mines.	Number of engines.	Equivalent in horse-power.
Coal or other fuel	1, 023	~~48, 062~~ 48.662
Iron	53	976
Other metals	101	1, 893
Total	1, 177	51, 531

Anzin Coal Mining Co.

The Anzin Coal Mining Company.

The Coal Mining Company of Anzin, as has been mentioned, is the largest in France. Its property covers 28,054 hectares, or about 108 square miles, and it produces annually above 2,000,000 tonnes of coal, employing 15,000 men, 12,000 below ground and 3,000 on the surface. If the facilities for drainage were good, from 5,000,000 to 6,000,000 of tonnes might be produced.

Extent and production.

Excellent exhibit: statistical and geological.

The exhibit of this company was particularly complete and instructive. Not only was very full statistical information furnished, but geological specimens illustrating the deposits were to be seen, as well as samples of coal and of artificial fuel, the tools employed, and, above all, a magnificent model of a portion of the coal-seam, with the underground and surface works accurately carried out to a scale of one-tenth. This model was as large as a small house. A passage led into the lower part of the structure, where the folding and faulting of the coal-seams and their relations to the overlying and underlying strata were admirably exhibited. The passage also led to a representation of the

Model of mine and mode of exploitation.

FRANCE.

underground working, where were seen the division of the ground on the panel-work plan, the method of breasting the coal, the transportation of the cars by the tail-rope and endless-chain systems, and the hoisting through the shafts, in complete detail. The safety apparatus is that of Cousin, mentioned elsewhere. Ascending a stairway one reached a model of the surface works, including the buildings, engines, coal-screens, etc. In short, from the excellent disposition and execution of the model, the mines could be studied almost as well, and much more easily, than on the ground.

Coal Mining Co. of Anzin.

Model of the mines and works.

The Anzin Company washes its own coals, and manufactures coke and artificial fuel. This latter branch is one of great importance, the product being no less than 150,000 tonnes per year. For the purpose of sustaining it, the company has been obliged to establish a tar distillery, the liquid products of which are rectified and sold. The company owns 845 coking furnaces and manufactures 300,000 tonnes of coke a year.

Coal washing: coke and artificial fuel.

The usual arrangements for the material and intellectual welfare of the workmen and their families are provided on a liberal scale by the company.

Products of the French smelting works.

Smelting works.

To supplement the foregoing tables, information is given below concerning the yield of the French metallurgical industries. In this connection it is important to observe, what has already been noted, that French works draw a very large portion of their ores and crude metal from abroad.

Iron and steel produced in France.

Iron and steel produced in France.

Years.	Pig-iron.	Bar-iron.	Steel.
1819	112, 500	74, 200	....
1826	....	....	4, 915
1830	266, 362	138, 469	....
1840	347, 774	237, 379	9, 263
1850	461, 653	246, 196	10, 981
1860	898, 353	532, 212	29, 849
1870	1, 178, 114	830, 786	94, 387
1876*	1, 395, 657	870, 312	230, 829

* These data differ somewhat from those given in the "*Annuaire des Mines, d'après le service des mines.*"

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Other metals produced in France.

Production of other metals than iron in France.

Metals.	1863.	1867.	1872.	1876.
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*
Copper and brass	14, 762	18, 016	21, 455	25, 085
Lead and litharge	23, 652	27, 761	21, 486	27, 163
Zinc, crude	1, 175	3, 485	8, 245	....
Nickel, crude	....	....	877	12, 783
Aluminium, crude	1	1. 7	1. 8	....
	Kilos.	*Kilos.*	*Kilos.*	*Kilos.*
Silver, fine	44, 409	41, 080	34, 454	48, 914
Gold, fine	500	737	410	850

Giant powder.

Giant-powder.

Relative explosive power of dynamite and gunpowder.

Production in Nobel & Co.'s factories in Germany and Austria.

It is familiar to every one that the use of dynamite or giant-powder has increased enormously during the last years, in consequence of its greater explosive power, which may be estimated at from four to five times that of ordinary black powder; indeed, according to experiments made by order of the Prussian Government, the relation is as 1 to 6.7. Exact data as to the quantity of dynamite used are not accessible, but from 1875 to 1878 the factories of Nobel & Co., in Germany and Austria, alone manufactured 2,667 tons a year of this explosive, which is equivalent to about 10,000 tons of black powder per annum, which is not far from the amount of the latter yearly produced in England.

Relative danger of nitro-glycerine and gunpowder works.

As to spontaneous decomposition and ignition.

Behavior of frozen nitro-glycerine.

The preparation of nitro-glycerine explosives has been popularly supposed to be excessively dangerous. Figures, however, would seem to show that this is a mistake, at least when the operations are conducted with skill and care. There were only two explosions involving loss of life in the German and Austrian dynamite factories above mentioned, against twenty-four in England in the saltpeter-powder factories during an equal period. A dozen years or more of the use of dynamite have also shown that when made with even moderate care spontaneous decomposition and ignition do not take place, at least within four or five years after the material has been prepared. Another point upon which some misapprehension has existed is the behavior of frozen nitro-glycerine. It has been supposed that in the solid state nitro-glycerine and the explosives of which it is the base were much more dangerous and more easily fired. It appears to be true that cutting frozen nitro-glycerine with an iron tool may induce an explosion; it is said, however, that an explosion may even more readily be produced by similar means at a temperature exceeding the melting point of nitro-glycerine (7 or 8 degrees C.). In experiments made by artillery officers in Austria it turned out that fluid nitro-glyce-

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rine placed upon an iron plate ~~has~~ was exploded by the impact of a rifle-ball at a distance of a thousand paces, while when frozen the distance had to be diminished to sixty paces in order to produce the same effect. It is also known that much stronger percussion caps have to be used in firing cartridges of frozen dynamite than in those where the explosive is in its normal pasty condition.

Behavior of frozen nitro-glycerine.

Besides samples of the ordinary preparations of nitroglycerine, there was exhibited at Paris a new explosive invented by Mr. Nobel, and called *dynamite-gum* or *explosive-gum*. This is a mixture of collodion with nitro glycerine containing from 93 to 94 per cent. of the explosive compound. The two substances are mixed in such a manner that the product forms a gelatinous solid. In this new shape the nitro-glycerine exhibits somewhat different properties from those of the well-known preparations. When not confined—exploded, for example, on a piece of boiler plate—the dynamite-gum produces less effect than No. 1 giant-powder; on the other hand, when confined—as, for instance, in a drill-hole—the effect is 50 per cent. greater. The new explosive is, furthermore, vastly less sensible to shocks than other similar mixtures. A chassepot ball, striking the gum at a range of only 25 meters, failed to produce an explosion. It is consequently applicable to the filling of shells and to other military uses. Furthermore, water has no effect upon this substance. As to the permanency of the compound, the invention is too new to speak with absolute certainty; but cartridges kept for over a year in the air and under water show no sign of any change.

Dynamite-gum.

Its nature.

Behavior.

Less sensible to shocks.

Water resisting quality.

In a private letter the general manager of the *Société Générale pour la Fabrication de la Dynamite* says: The comparative tests which have been made on blocks of lead shown in our exhibit gave the following relations between the various explosives by volume. These relations may be regarded as those of the strength of the powders:

Explosive power of respective powders, etc.

Military or mining powder	1
Dynamite No. 3	5
Dynamite No. 1	7.5
Dynamite No. 0 (cellulose base)	8.5
Dynamite-gum	10

Safety apparatus.

Safety apparatus.

There were various safety apparatus exhibited at Paris, for the most part modifications of devices already familiar to mining men. M. Cousin's apparatus, invented a couple of years before the Exhibition, however, possesses some

Cousin.

Cousin's safety apparatus for elevators.

novel features. The clutch, instead of acting on the guides in case of accident, clasps a rope extending from the top to the bottom of the shaft. The lower end of this safety rope is fixed, but the upper end passes over pulleys, and is attached to a string of graduated weights, the upper one of which is the lightest. Consequently, when the safety clutch seizes the rope the arrest of the cage is not instantaneous; the safety rope is drawn down until, one weight after another being raised from the ground, the cage and its load are counterbalanced.

Description.

This is an ingenious construction, and no doubt insures a gradual arrest of the motion of the cage, and prevents the destruction of guides. Whether American mining men will agree with the managers of some of the most prominent French mines, that the difficulties experienced with the more usual constructions are sufficient to warrant the complication involved by M. Cousin's plan, seems questionable.

Somewhat complicated.

Anti-overwinding apparatus.

Safety apparatus providing against overwinding are becoming general in France. The fundamental idea is commonly to detach the cage automatically from the hoisting rope when it approaches the sheave dangerously. The attachment between hoisting rope and cage is so constructed that on striking a beam, passing through a ring, or, probably best of all, upon entering a hollow truncated cast-steel cone, the cage is detached.

Description of its action.

Its fall is then prevented by the action of the same apparatus upon which dependence is placed in case of the breakage of the hoisting rope. Provisions against overwinding should be more common in America than they are, even in our most important mining districts, and miners will readily recall frightful accidents arising from the lack of this precaution.

Special regulations looking to the safety of the miners exist and are strictly enforced in France, as in all the great European countries.

Annual percentage of killed and wounded by accidents.

The number of accidents however is large, nearly two per cent. of the men being killed or wounded each year. More exactly, in the year 1875, which was not an exceptional one, 2.06 men per 1,000 employed in mining were reported as killed, and 17.73 per 1,000 as wounded. The coal-mining interests of France so greatly exceed the rest, that one might suppose the accidents mainly ascribable to the peculiar dangers met in the extraction of coal. Such, however, does not seem to be the case.

Injuries from fire-damp less frequent than those from caving.

The injuries arising from explosions of fire-damp and asphyxia amount to only 8 in 10,000 coal miners. A large majority of the accidents, especially of the fatal ones, in all classes of mines, are caused by the caving in of ground.

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Improvements in machinery of French mines.

The advances in the art of mining in France during the last ten years present no especial peculiarities. Steel cables have been introduced instead of iron to a very great extent; wooden and iron guides have replaced ropes used for the same purpose; the lowering and hoisting of miners on the cage, instead of the use of ladders, has become prevalent; rotary pumping engines have been introduced; safety lamps have been improved, but electric illumination has made little progress; ore-dressing and coal-washing have been greatly developed; and the manufacture of artificial fuel has become a very large business. In this last branch of industry pitch has been almost altogether substituted for tar, giving the advantages of lumps, which are more solid, and burn with less smell and less smoke. An addition has been made to the metallurgy of lead and silver by the introduction of the *Luce and Rosan* process, which is a Pattinson process, in which the stirring is effected by a jet of steam. By this process the complicated mechanism necessary in what is called the mechanical steam-pattinsonizing is avoided; the steam assists in the oxidation of impurities, and the concentration of the silver can be carried somewhat further than by the old method of manipulation. This process has been introduced into America (at Eureka) and into England.

Artificial fuel.

Luce & Rosan adaptation of the Pattinson lead-silver process.

Some general notes on models.

Models of mines and works.

One of the most noteworthy exhibits of this kind was the model in wire ~~composed~~ exhibited by *La Compagnie des Fonderies et Forges de Terre Noire, Lavoulte, et Bességes*, presenting in relief and at one view the form and features of the surface and the subterranean works of the mines at their proper relative depths beneath the surface. The subject of this plan comprised a superficial area about 3 miles long by 2 miles wide, perhaps a little more or less, beneath which were represented a portion of the underground works of the collieries and iron mines belonging to the company. ~~above ground~~.

La Compagnie des Fonderies et Forges de Terre Noire, etc.

Description of model.

This method consists in producing the form of the surface in equidistant contour lines represented by wires of sufficient strength, the contour in this instance being taken at intervals of five meters in vertical distance, and the horizontal wires being held in their relative position by other wires joining them transversely in such manner as to form a net-work presenting the relief of the surface.

Mode of development of plan.

This model was constructed by first preparing a map of the surface, on which the contour wires were carefully drawn.

Preparatory map.

FRANCE.

Each of these contours was then reproduced in brass wire. In order to place these contour wires in their proper relative position a series of profiles in wood was employed, formed of thin boards set up vertically and parallel to each other, each cut on its upper edge so as to form the profile of that part of the surface of which it represented a section. The contour curves in wire were placed upon and supported by the system of profiles, and after being adjusted precisely to their proper relative position were joined together by other smaller wires, so placed as to bind the net-work firmly, and at the same time to represent other features of the surface, such as the crests of the ridges, the beds of the ravines, the boundaries of properties, the lines of roads, the courses of streams, etc.

Model of Terre-Noire mines and works.

Mode of construction.

The surface works,

Upon this net-work it was then easy to place the representation on the desired scale ($\frac{1}{1000}$, or 83⅓ feet to the inch) of the principal buildings and works on the surface, removing finally the wooden profiles from underneath, and substituting for that means of support a sufficient quantity of small uprights of the desired length, and at convenient points.

and underground workings.

The underground works of the mines were shown in similar manner. The various drifts, tunnels, and cross-cuts were represented by horizontal wires, each having the form required to correspond to the course and length of the work represented by it. These horizontal wires being placed in proper relative position beneath the surface net, were connected with other wires corresponding to the shafts, inclines, winzes, etc., and other accessory works of the mine, the whole being also supported from below by uprights fixed at convenient points. Moreover, the surface wires and those of the underground works were made to show the main features of the geological formation, by coloring them with different tints indicating the various rocks exposed on the surface or traversed by the mining works below ground. The general effect of this method of representation is exceedingly good. The form of the surface, its nature expressed by color, and the relative position of all the objects shown upon it, were brought out in bold relief, while the spaces between the wires afforded a clear view of all the works lying beneath.

Colors to show geological formation.

Excellent effect.

Models in plaster and glass.

There were also various interesting models exhibited in plaster and in glass. Some of the plaster models were left in steps or terraces, the edges of which represented the contour lines. The glass models were made up of sheets set at regular distances. On each plate was drawn in transparent color a vertical or horizontal section of the ground corresponding to the scale of the model.

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Algeria.

Algeria.

Statistics of mines.

Sixteen mines were being worked in Algeria in 1876, besides various prospects. In 1876 3,618 workmen were employed in making excavations and in extraction of ore. The following table gives the situation and production of those mines yielding over 5,000 tons in the year 1876:

Algerian mines in 1876.

Situation and production of mines.

Situation of the mine.	Nature of the ore.	Number of mines.	Production in tonnes.
DEPARTMENT OF ALGER.			
Soumah	Iron	35	11, 936
Gourayas	Iron and copper	82	7, 500
Zaccar	Iron	190	40, 000
Qued Messelmoun	Iron	222	12, 000
DEPARTMENT OF ORAN.			
Beni-Saf	Iron	310	50, 000
Djebel Haronaria	Iron	220	14, 000
DEPARTMENT OF CONSTANTINE.			
Kef-Oum-Theboul	Lead	387	12, 162
Kharizar	Iron	167	21, 636
Aïn-Morkha	Iron	1, 471	366, 446
Iron-ore mines		2, 830	568, 320
Other mines		788	17, 412
		3, 618	585, 732

Steam-engines employed.

In 1875 the iron mines employed eighteen steam-engines, giving altogether 349 horse-power; the other mines, four engines, amounting to 60 horse-power.

No blast furnaces in Algeria.

Algeria possesses no blast furnaces. The greater part of its ores goes to France. Next to France, England buys the largest portion of iron ores; then follows Belgium, and then the United States.

Importation and consumption of coal.

The importation and consumption of coal for Algeria is seen from the following:

Year.	Imported from—		Consumed.
	England.	France.	Total.
	Tonnes.	*Tonnes.*	*Tonnes.*
1873	64, 390	9, 950	74, 340
1874	58, 360	18, 260	76, 620
1875	59, 450	12, 400	71, 850

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Algeria.

The quantity of ores exported from Algeria has been as follows, in tonnes of 2,205 pounds:

Export of ores.

Year.	Iron.	Copper.	Lead.	Total ore.*
1869	215, 205	5	2, 827	218, 036
1870	169, 429	65	3, 497	172, 991
1871	172, 333	1	2, 611	174, 945
1872	391, 190	111	3, 514	394, 814
1873	420, 700	72	5, 446	426, 214
1874	460, 273	493	3, 050	463, 815
1875	522, 630	3, 020	2, 355	528, 005
1876	456, 812	6, 372	1, 615	464, 799
Total	2, 808, 566	10, 138	24, 913	2, 843, 618

*The original is given in *quintals*, or tenths of tonnes; consequently, there is an *apparent* error in the last figures of some of these totals.

Effect upon Algerian ore production of the development of the Pyrenean mines.

Up to 1876 Algeria escaped the effects of the financial depression prevailing all over Europe. Spain had for some years been involved in civil war. The mines of Biscay were shut down, and African ores, to the exclusion of all others, supplied the steel works. But since that time two causes have modified the situation—the pacification of Spain on the one hand, and on the other development of the mines of the Eastern Pyrenees, which have been put in communication with the sea and with the French system of roads by the completion of the railway from Perpignan to Prades. This checked the Algerian production, but only momentarily. The high quality of her iron ores, better appreciated every day, inspires the Algerines with confident hopes.

Guiana.

Guiana.

Gold.

The exportation of gold since 1875 has been not far from 2,000 kilos per year, representing a value of 6,000,000 fr., say $1,250,000. These are the official figures, but they probably fall considerably below the truth.

New Caledonia.

New Caledonia.

Geological peculiarities.

The geological formations observed in New Caledonia are of a very complex nature; but, speaking in general terms, it is easy to distinguish three distinct geological regions. First, fragments of primitive and of crystalline rocks, which occupy the extreme northern end of the island; second, serpentine rocks of great depth, which form, as it were, the skeleton of the island; third, metamorphic beds and sedimentary rocks associated with melaphyres, which occupy the west side. In respect to the metallic wealth which they contain, each one of these regions presents a special interest.

Gold and copper.

Gold and copper are found in veins traversing the primitive rocks at the north of the island, the

FRANCE.

New Caledonia.

serpentines contain an abundance of iron, chromium, and nickel, and the sedimentary rocks at the west inclose coal seams.

Iron, chromium, nickel, coal.

It was at one time supposed that New Caledonia would equal Australia and New Zealand in its mineral resources, but these hopes have been for the most part disappointed. Some gold has been obtained, but the mines appear to have been abandoned, and it is said that in depth the metal is replaced by pyrites. The coal seams are inclined at a high angle, and, so far as worked, yield only poor fuel. It is doubtful whether they can ever be made to pay.

Gold and coal enterprises have not thriven.

Thus far the most important ores furnished by New Caledonia seem to have been those of nickel. As for the yield of the mines, no authoritative statement has been found.* The New Caledonian nickel industry, however, possesses considerable technical interest, because it is founded upon a new ore, which is treated in part by new processes. On this account the following notes, which have been taken mostly from a paper by M. Jules Garnier, read before the Society of Civil Engineers, will be read with interest. It will also not be amiss to call the attention of engineers to the possible discovery of deposits of the new nickel mineral.

Importance of the nickel ores.

Jules Garnier.

M. Jules Garnier was the discoverer of a new nickel ore in New Caledonia, which has since been named *garnierite*. This metal is a hydrated silicate of nickel and magnesia, and occurs in various forms in serpentine rocks. Its formula is $(MgO,NiO)\ SiO_2+nH_2O$.† It is accompanied by compounds of iron and chromium and cobalt mineral.

Garnierite.

Its nature and location.

As is well known, the methods of extracting nickel from such ores as have hitherto been treated consist in concentrating the nickel in a regulus or speiss, dissolving the compound sulphide in acids, precipitating the nickel as oxide, and reducing the precipitate with carbonaceous substances.

Process with the usual nickel ores.

As garnierite contains no sulphur or arsenic, the application of ordinary methods to it involves the addition of minerals containing those substances in sufficient quantities to take up the metal. This mode of treatment M. Garnier considers economical under some circumstances (for highly ferruginous ores of low nickel tenor), but under many conditions, and with a large proportion of the ores, it was very desirable to invent a process less indirect, since the sulphur

Addition of ingredients to Garnierite to render it amenable to old process.

* In 1876, 463 tonnes of nickel ore, regulus, etc., were imported into France. In 1877 the importation rose to 3,790 tonnes. The increase is probably due, at least in great part, to the New Caledonian mines.

† According to M. Garnier, Dana's formula differs slightly.

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New Caledonia.

and arsenic are added only to be again separated from the nickel.

Garnierite: an ore of nickel.

M. Garnier has made numerous experiments with a view to devising such a process. The direct application of acids to the ore is ineffectual, since iron and nickel are not separated thereby. Experiments were also made upon the fractional reduction of the ore. The reduction was undertaken at a low temperature, at which it was supposed that nickel might be reduced, while the iron, or the greater part of it, would remain in an oxidized condition. This also proved impracticable, in part on account of the highly divided condition of the reduced nickel.

New process.

Ferro-nickel.

Finally, M. Garnier made experiments, and this time successfully, in the direct reduction of the ores in such a manner as to produce a pig-iron containing large quantities of nickel—a metal which may be called *ferro-nickel.* This process is carried out in a cupola furnace of about four meters in height, with cold blast at low pressure. Under these conditions, and with the proper smelting mixture, only a portion of the iron is reduced; the remainder goes into the slags, unaccompanied by nickel, and of course greatly increases its fusibility. When, as is sometimes the case, the ore contains only a small amount of iron, an addition of some ferruginous mineral must be made. The following are analyses of some of the ferro-nickels produced from an ore containing about equal quantities of iron and nickel:

Analyses of ferro-nickels.

Iron	46.55	41.30	38.70
Nickel	50.91	54.25	59.00
Carbon	3.04	4.45	2.30

A complete analysis gave:

Nickel	60.90
Iron	33.35
Silicon	0.85
Carbon	3.90
	99.00

As might be expected, the double carbide of iron and nickel is more fusible than the carbide of either metal by itself.

Character of ferro-nickel.

Its use.

Ferro-nickel-copper alloy.

Ferro-nickel possesses great malleability, is easily worked under the file, takes a high polish, and shows a fine grained or foliating fracture. A large proportion of the nickel employed is used in the manufacture of German silver and other alloys of copper and nickel, bearing in trade a variety of names, such as argentan, alfenide, etc. German-silver founders prefer to purchase their nickel already alloyed with a certain amount of copper. To satisfy this demand

FRANCE.

New Caledonia.

Ferro-nickel.

Refining.

the ferro-nickel is refined in a reverberatory furnace in the presence of copper, which, perhaps, also tends to preserve the nickel from oxidation. The refining of the ferro-nickel proceeds similarly to that of pig-iron, silicon oxidizing first of all, and the oxidation of the carbon soon manifesting itself by the boiling of the liquid mass and the ejection of carbonic oxide.

Oxide of manganese and other substances of a similar tendency are added to hasten the oxidation, and, when necessary, silicious fluxes to take up the oxide of iron formed. The character of the residual alloy is determined from time to time by testing samples, and when the desired point is reached the metal is cast. If pure nickel instead of an alloy is desired, the process is similar, except in regard to the addition of copper.

Production of useful ferro-nickel alloys.

M. Garnier is now engaged in the attempt to produce technically useful alloys of iron and nickel. The somewhat discordant results which chemists and metallurgists have hitherto attained in experiments on this subject M. Garnier ascribes to the great sensitiveness of nickel to the presence of a variety of foreign substances. The study of the effect of impurities upon the metal will no doubt lead to a knowledge of the processes necessary to eliminate them.

III.

GREAT BRITAIN.

THE BRITISH EXHIBIT.

The period 1876-'78 not favorable for improvements in mining and metallurgy.

The period which has elapsed since the American Exhibition has not been a favorable one for the introduction of era-marking improvements in mining or metallurgical operations. The prolonged depression of business, the often short-sighted discontent of the laboring classes, and the pressure of foreign competition have forced those interested in such undertakings rather to endeavor by strict attention to economy in detail to keep already invested capital intact than to embark in new schemes. While, therefore, the British exhibit had much to offer which was of importance to professional engineers, there was little within the scope of this report to excite unprofessional attention. Many exhibits in Class 43 were, as it seemed, unnecessarily uninteresting. An array of samples of metal, grouped under the name of the manufacturers, showing fractures, or twisted to show toughness, is not indeed without its value; but it is certainly desirable that something more should be shown—samples of the metal in different stages of preparation and manufacture, models and drawings of apparatus, and the like. Exhibitors interrogated on this point sometimes answer: "We come to show our wares, not to teach others how to compete with us." But an international exhibition is not simply a gigantic advertising establishment; and even from the merely commercial point of view greater liberality in this direction is desirable than was shown by English exhibitors. It would be a strange mine that could show no fine samples of ore, a remarkable metal works which was unable to produce some bars it was not ashamed to exhibit. But those who have orders to give desire something more than this. They want evidences that they can depend on receiving uniformly good value. More ample exhibits tend strongly in this direction. Nor is the reputation of any establishment so high that it cannot be raised. To go outside of the range of this report for an illustration, the Creusot steel works has long enjoyed a high reputation; its exhibit in Paris was hardly characterized by novelty, but the effect of the admirable workmanship shown, combined with that of the models and drawings of apparatus,

Good products exhibited but the means withheld.

Nature and value of the reputation obtained.

Creusot steel works.

mills, dwellings for workmen, schools, etc., was such as probably to raise the works in the estimation of every visitor to its display, which was as crowded as the fine arts department. The fear of assisting competitors, too, is quite illusory. The history of modern technology teaches nothing more certainly than that the interchange of information is a mutual benefit. Mr. Bell is not less successful as an iron-master because, at the cost of immense labor and expense, he has taught the world so much about iron-smelting; and he would be the first to acknowledge the assistance he has received from others.

Creusot steel works.

I. Lowthian Bell.

In view of the absence of novelties of such a character that their description does not seem more in place in a technical journal than in a government report, it appears to me that the purposes of this publication, so far as Great Britain is concerned, will best be fulfilled by presenting a sketch of the recent growth and present condition of the mineral industry of that country. Information on this subject is constantly published, but commonly in so fragmentary a form that few of those most interested have leisure to piece the scraps into any consistent shape, important though it certainly is for each man engaged in mining or metal working to acquaint himself with the dangers to which the industry has been exposed, the tendencies it has exhibited, and, as far as may be, with the probabilities it offers. The following pages make no pretense of offering more than a sketch of the subject, although the labor of producing them is scarcely measured by their number.

What the author proposes to himself in the report on Great Britain.

Statistical review of the mineral industry of the United Kingdom for the years 1860, 1865, 1870, *and each year since.*

Statistical review of mineral industry of Great Britain.

One of the most important of the questions which are suggested by an international exhibition is: "Where do the ores, metals, and coal come from, and where do they go to?" An answer to this question, so far as the United Kingdom is concerned, goes very far towards forming a reply to the inquiry in its most general form, and cannot fail to be of interest and value to those who have to do with the products of mineral industries, whether as producers, consumers, or traders. Mining and metallurgical industries are, like others, very sensitive to disturbances arising from temporary causes, and a statement of their condition at any one period of time may consequently prove misleading. A systematic statement for a series of years, on the other hand, will exhibit the effects of temporary conditions, without obscuring the tendencies of the time, and assist the

As to the source and destination of the mineral products.

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judgment in estimating the probabilities for the future. In the following pages I have endeavored to give, in the most condensed form, a review of the mining industry and commerce of Great Britain for the years 1860, 1865, 1870, and each year since, drawing the material for my data mainly from the yearly memoirs of Mr. R. Hunt, entitled "Mineral Statistics of the United Kingdom," and from "The Economist."

R. Hunt, "Mineral Statistics"; "Economist".

The market price of commodities regulates both the consumption and the production, for the price determines the conditions under which profit is possible, either to the consumer or the producer. No discussion of the mineral industry is, therefore, of much value in which this all-important factor is lost sight of. England, moreover, is the great metal market of the world, and English prices of metals control those obtainable at all commercial centers. The prices in London are consequently of great general importance, and are given for the series of years under discussion in Table I. A change in prices indicates, of course, a change in the relations of supply and demand, but no invariable inference is to be drawn from it as to the prosperity of the industry productively concerned. The price of a metal may fall in consequence of improvements in processes, such as followed the inventions of Bessemer and Siemens in steel making. Steel used to cost in England from \$200 to \$300 per ton, according to quality, when nearly all of this metal was produced by the blister-steel process, followed by remelting in crucibles; but steel rails were sold in November, 1878, at less than £7 (\$34) per ton, delivered. Discoveries of new sources of supply, such as the Australian tin fields, may also bring down the price. The market, however, may also decline in consequence of disturbances in consumption, and a decrease of general prosperity, as has lately been the case. On the other hand, a rise in price may originate in a diminishing supply, as has been the case at times with tin and graphite, or in new applications (nickel plating), or in a sudden increase of consumption, based rather upon hope than upon that normal development of civilization with which the mining industry might keep pace. Iron of an ordinary quality is the metal most affected by the inflation or depression of speculative enterprise, because it enters more largely than other metals into the construction of railways, steamships, and the like. Cleveland pig iron at the works was worth, in 1871, £2 9*s.* 6*d.* (\$12.03). In February, 1873, it rose to £6 7*s.* 6*d.* (\$31). At the close of the year 1877 it

England the great metal market of the world.

Table I (page 216).
London prices of metals.

Causes of fluctuations in prices:

Cheaper processes.

New sources of supply.

Disturbances in consumption and general prosperity.

Diminishing supply.
New applications.

Ordinary iron the most fluctuating in price.

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was worth only £2 4*s.* 6*d.* ($10.81), and it has recently been quoted at considerably below £2. Lead, in the mean time, has varied less than 30 per cent. of its lowest value.

Causes of fluctuations in value of minerals.

The *tendency* of the prices of metals and minerals it is scarcely possible to discuss from a general point of view with profit, because the price is dependent upon so many factors; among others, the prosperity of one branch of mineral industry, viz, gold mining. The more largely the cost of manipulation enters into the value of a metal, the greater will be the downward tendency of the price, because "improved" processes means "cheaper" processes. Contrast with the variation in the price of steel mentioned above that of coal, which was cheaper in 1860 than in 1878, the increased depth of the pits and the higher wages having more than offset the improvements in coal-cutting machinery, etc. It cannot be doubted that in the case of copper, too, the development of the extraction of metal from "burnt pyrites" has had a considerable effect upon the price. The fluctuations in the price of silver have been voluminously discussed of late. The broad facts of the case seem to be that, in view of the immense production, it became manifestly impossible to maintain a definite relation of value between the precious metals; that thereupon gold was adopted as a standard by Germany and the United States, and the coinage of silver limited by the Latin Union. The abandonment in so great a measure of the principal use of silver, together with new discoveries, depressed the market violently, and would have done so still more had not the absorption of silver in the East increased. It is significant of the fact that silver has depreciated instead of gold appreciating, as some have maintained, that the East has absorbed silver in direct ratio to the depreciation, as might have been the case with any other commodity. Silver, as is well known, is circulated in the East in great part not by count, but by weight and fineness, like other merchandise. While all the metals are at lower rates than in 1860, wages have not receded to old standards in Great Britain.

Coal.

Copper.

Silver.

Uno-metallic standard.

Indian absorption of silver.

With cheaper metals wages have not receded to old standard.

Miners' wages in Scotland, 1858–1877.

Wages of average miners in Scotland.

"Economist," March 9, 1878.

	s. d.
1858	3 0
1868	3 9
1873	8 6
1877	4 3

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This is in part attributable to the higher price of the necessaries of life,* brought from constantly increasing distances, and in part to the difficulty the workmen experience in returning to the more penurious habits of their predecesors.

Table I (page 216).
London prices of metals.

Table I shows the average price of common metals and of coal in England for the series of years under discussion, the same being obtained from the average price of each ~~work~~ week. In Table II the same prices are converted into American money. In these tables the miner or metal merchant will read a record of technical improvements, discoveries of ores, political convulsions, legislative experiments, of wild hopes and desperate panic, such as could in no other way be set before him in the same space. Causes for some of the fluctuations have already been indicated, and reasons for others may appear later.

Table II (page 217).
London prices in American money.

Table III (page 218).
Production of minerals in Great Britain.

Decrease in copper.

Tin, lead, and silver stationary.

Table III exhibits the quantities of the several metals and minerals produced in Great Britain for each year. The amount of copper produced from British ores, it will be seen, is decidedly decreasing. Tin, while it has undergone somewhat violent fluctuations in quantity, maintains itself tolerably, in spite of the great reduction in price since the opening of the Australian mines. The quantity of lead produced in the years 1860, 1872, and 1877 differs but little. Silver follows lead very closely, as would be expected, since the silver extracted in Great Britain from native ores is almost exclusively obtained from lead.

The same quantities of different metals correspond to very different quantities of ore; the relations, however, are so nearly constant that it would be scarcely worth while to give the variations from year to year. Mining men may, nevertheless, be interested in knowing approximately the relations prevailing at British mines.

Relation of quantities of metal to ore.

Metallic contents of British ores. †

In the year.	Tin in 100 ore.	Copper in 100 ore.	Zinc in 100 ore.	Iron in 100 ore.	Lead in 100 ore.	Silver ounces in 1 ton lead.
1860	64	6¾	28	47½	71¼	8.68
1865	64	6⅛	25	48¼	74⅜	10.78
1870	67	7	29	41	74¾	10.69
1875	68¾	7	28	38½	73⅞	8.49

* From 1845–'50 (6 years), wheat averaged 53*s*. a quarter, and beef of inferior quality was 4¼ to 4½*d*. per lb. In 1877 wheat was 57*s*., and beef 5½ to 6¾*d*. *Ibid.*

† "Mineral Statistics," in part by calculation.

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The rise in the percentage of metal in the "black tin" is no doubt due to increased care in the concentration so important with tin-stone. The zinc ore is almost exclusively "black jack." The diminished percentage of the iron ore is due to the increase of the proportion of British iron produced from the argillaceous carbonate of the Middlesborough district, which is low in grade.* In 1870 the North Riding of Yorkshire and the county Durham produced $26\frac{3}{4}$ per cent. of the total iron smelted in the United Kingdom. In 1875 this district produced nearly 32 per cent.

Causes of fluctuations in production of metal per given quantity of ore.

The Cleveland district.

Table III gives the metals produced from British ores exclusively, except in the case of iron, the figures for which include the pig produced from imported iron ores and "purple" ores, the residue of the pyrites-burning process. The quantity of imported iron ore will appear later. It amounts to less than 10 per cent. of the ore smelted. As the residue of the pyrites-burning after extraction of copper is used as an ore, both in the blast furnace and as "fettling," its composition may, perhaps, be more appropriately given here than later. Mr. F. Claudet found in "purple ore"—

Table III (page 218).

Production of native minerals plus imported iron ores.

Composition of the purple ore; the result of pyrites burning

Ferric oxide	96.00	=67 per cent. iron.
Lead (as sulphate)	.75	
Copper	.20	
Sulphur	.36	
Lime	.40	
Insoluble	2.11	
Phosphorus	none	
Soda	.10	
Total	99.92	

The amount of iron produced in 1877 was within about 2 per cent. of the maximum production in 1872. Taken in connection with the table of prices, this fact affords a remarkable example of the extent to which the consumption of a metal can be stimulated by reduction in price. The year 1877 was assuredly not marked by enterprise, especially of the character which signalized the period of inflation, and yet nearly as much iron was consumed. It would be interesting to trace the details of this consumption were this the place for it. The production of zinc has increased greatly, and was scarcely checked by the panic of 1873. The same remark applies to salt and clay, especially the latter, which is about six times what it was in 1860 The quantity of pyrites mined has fallen off, but the decrease has been far

Comparison of production and prices of iron in 1872 and 1877.

Increased production of zinc, salt, and clay.

* Typical Cleveland iron-stone contains 30 per cent. iron. See Bell, "Chemical Phenomena of Iron Smelting," p. 4.

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Immense output of coal.

more than compensated by increased importation. The output of coal is astounding and highly indicative particularly when it is remembered that as improvements in the economy of fuel are constantly being made, the effective application of heat increases in a still greater ratio than the quantity of coal mined. According to Siemens, the annual improvement in the economy of fuel is equivalent to about 4 per cent. of the consumption. At present about 90 per cent. of the fuel is ineffectually consumed or wasted. The output of coal was diminished by the panic only for a single year, and in 1877 was about 7,600,000 tons greater than in 1873.

Value of annual improvement in methods of economizing fuel.

Table IV (page 219).

Value of annual production of minerals in the United Kingdom.

Table IV, the value of the metals and minerals produced in the United Kingdom, is compiled from the yearly issues of the "Mineral Statistics." It is difficult to understand precisely how the items have been estimated. The value of any metal produced in any year would seem to be the quantity produced multiplied by the market price, and this view is borne out by many phrases in the "Mineral Statistics," and by the coincidence of the values there assigned, in a large proportion of cases, with the values arrived at by the method of calculation indicated. In a large number of cases, however, the values given differ from the product of the amount produced into the market price. Thus, while the value of the pig-iron produced in 1870 and 1871 is the same which results from multiplying the total product by the average market price of Cleveland pig at the Tyne or Tees for each of these years, the value of the pig-iron produced in 1873 corresponds to an average value per ton of only £2 15*s.*, which is £1 15*s.* below the lowest price paid in England for the cheapest iron in the district where it was produced in that year, and £3 below the average price of the same iron. In reply to an inquiry, Mr. Hunt writes: "I must beg you to observe that the mean price of Cleveland pig, which you quote, is from the 'Market Prices of Pig-Iron,' whereas, the value given in the introduction is an estimate of the value at the place of production, determined by private inquiry." But as the market prices are given "at works," or for the immediate neighborhood of the works, this explanation does not appear to me entirely satisfactory. It is impossible to suppose, in view of the phraseology and of many explanations in the "Mineral Statistics," that by "value" is meant "cost of production."*

Discrepancies between the results of the price and product and the statement of value of product.

*In the "Mineral Statistics" for 1870 Mr. Hunt says of the product of pig-iron, "This quantity, estimated at the mean average *price* at the place of production, would have a value of" so and so, which value is adopted in the general summary and corresponds to the market price

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For the years 1872–1876, both inclusive, the value of pig-iron is uniformly estimated at a price below the average price of Cleveland pig. The values of the other metals and minerals correspond more closely with the market prices, though some not inconsiderable variations are observable. Thus, the value of the copper product for 1870 answers to a price per ton which is over £4 higher than the average price of best selected copper for that year. Of course the sums total are proportionately affected. That for 1870 contains a further error, and should, apparently, read £47,946,300. The price of coal is assumed at from 5*s.* to 7*s.* 6*d.*

Discrepancies in the tables.

Importation, exportation, and consumption of metals and minerals.

Importation, exportation, consumption of minerals and metals.

The United Kingdom neither supplies its own smelters with all the ores they require nor its native consumers with the needful quantity of every metal. Great Britain, moreover, exports enormous quantities of metals and minerals to other countries. The importation, exportation, and consumption of the products of mining industry are so closely connected that it seems best to discuss them together and metal by metal, reserving for the present the subject of the sources of supply and the distribution of the material handled. The necessary facts for this discussion are not, in all cases, directly obtainable. Estimates, however, where unavoidable, have been made on assumptions which will be explained as the cases arise, and which it is hoped will approve themselves to the judgment of the reader.

The "consumption" of the metals and minerals is assumed, for the purposes of this paper, to be the amount retained in the country each year. The quantity retained is found by adding the importation to the production and subtracting the exportation. Of course it is not true that the amount retained each year is consumed in that year. A portion is, no doubt, usually stored, either for future use or exportation. For a series of years, however, it must be true that what is retained is consumed, and no other method of ascertaining the yearly consumption presents itself. The merely general correctness of the method will explain some of the fluctuations which will here and there be noticed. Doubtless many men of long experience in metallic commerce will recognize in some of these fluctuations periods when stock was allowed to accumulate on account of the

Mode of estimating consumption: the sum of the production and importation minus the exportation.

Reasons for suspecting the absolute accuracy.

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and value. The same remark and treatment is repeated in 1871. After this date I find no explanation of the method of arriving at the "value" given in the summary.

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unremunerative condition of the market, or when the state of affairs seemed to justify the policy of "holding for a rise." It is, however, foreign to the purposes of this paper to enter into any description of these exciting phases of the history of commerce. The metal imported into Great Britain is partly in metallic form and partly in the ore. In most cases the metallic contents of the imported ores is not published, but simply the quantity of ore, or its quantity and value. For the object of this discussion, however, it is essential to have an estimate of the quantity of metal contained in imported ore. Where the value of this ore is known I have supposed the relation of its metallic contents to its value to be the same as in the case of ores of British production. A rule-of-three calculation thus gives the desired datum. This is not strictly accurate, because in many cases an extra price is paid for the superior quality or purity of foreign ores. The influence of this disturbing factor must, however, be very small. In the comparatively few cases where only the weight of the imported ores is known, I have been obliged to assume their metallic contents to be near about, but a little higher, than that of British ores extracted in the same year. The importation of metal, the metallic contents of imported ore as estimated, the exportation, and the quantity retained in the country are given for each metal and mineral in Table V.

Imports in both the ore and metallic forms.

Mode of estimating value of metal in imported ores.

Importation, exportation, and consumption of minerals.

Table V (page 220).

Tin.

Tin.—The world's production and consumption of tin have greatly increased within the period of time under discussion. The output of Billiton first amounted to 1,000 tons in 1865, and the Australian mines only became important in 1873. The consumption (for example, in the form of "tin" plate in the canning of food) has grown proportionately, notwithstanding the various devices, to which the great fluctuations in the price of this metal have given rise, for making a pound of tin cover a greater and greater surface of iron. Except in the years 1873 and 1874, after the opening of the mines in Australia and before the erection of smelting works there, the amount of tin ore imported into Great Britain has been small. In the mineral statistics for 1860 and 1865 only the quantity of imported ore is given. The metallic contents are taken at 64 and 65 per cent.; that of British ore being somewhat less. For the remaining years the contents are calculated from the value. The latter method would also lead to the conclusion that the ore contained about 65 per cent. of tin, so that there can be no considerable error in the estimate. The exportation of tin is very large for the years 1874, 1876, and 1877, larger than the pro-

Billiton in 1865.

Australia, 1873.

Cheap tin-plate.

Large exportation.

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Tin.

Increased consumption.

duction from home resources. The consumption has exceeded the production ever since 1870, and Great Britain, which used to supply the world with tin, is now unable to meet her own demands, so much have these increased.

Copper.

Fluctuation in relation of native production and imported copper.

Copper.—As is well known, immense quantities both of metallic copper and of copper ores are imported into Great Britain. In 1860 the amount of this metal produced in the kingdom was slightly in excess of the metallic copper imported. With the exception of the year 1872, when the amount was exceptionally great, the importation increased steadily up to 1875, the home production decreasing the while to such a degree that in the last-mentioned year it was only slightly more than one-tenth of the importation. If the mines have retrograded, the smelting works have none the less flourished to such an extent that the metal produced from foreign ore treated in Great Britain in 1877 was twelve times as great in quantity as that extracted from native ores.* The larger part of the 50,000 tons, or so, thus separated is reduced from copper ores in Cornwall and

The new source of copper—from burnt pyrites.

at Swansea. Of late years, however, the extraction of copper from "burnt pyrites," containing about 4 per cent. of copper, by wet processes of recent invention has assumed great dimensions and importance. Mr. Hunt estimates the

Estimated amount.

amount of copper extracted in this manner in 1876 at 15,000 tons, and in 1877 at 17,000 tons, and states that the estimates in former years have been too low; a fact which accounts in part, but not wholly, for the enormous rise in the metallic contents of imported ore of late years according to the table. The "Mineral Statistics" records an increase

Imports of ore.

of about 40,000 tons in the import of foreign ore for the year 1877, but, unfortunately, from unenumerated countries. The exportation of copper from Great Britain is very large

Exportation of metal.

and has been very steady since 1870, averaging about 54,000 tons. In compiling the data for the exportation and for the importation a difficulty has been encountered in the fact that, in several cases, the value only of manufactured

Mode of estimating weight given in the table.

copper is given in the "Mineral Statistics." The weight has been estimated from the value, on what appeared to be sufficient grounds, at seven-eighths of the value divided by the price of best-selected copper for the year in question. As the quantities are small, from a few tons to a few hundred tons, any slight error in this rule will affect the result but little. A small amount of ore and foreign regulus is

* The metal reduced from foreign ores and regulus is given in the "Mineral Statistics" for each year except 1865. For that year I have estimated it by the rules presently to be mentioned.

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Copper.

sometimes exported from Great Britain. I have taken the metallic contents of such ore at 16⅔ per cent.* and that of the regulus at 25 per cent. The foreign regulus seems to have contained considerably less than 25 per cent. in the earlier portion of the series of years and considerably more towards its close. The quantity of copper retained for consumption in Great Britain is, according to the table, very irregular. The high price and active foreign demand in 1871 explains the small amount retained during that year, and the impetus given to manufacturing and short stocks account for the large figure for 1872. As residual quantities, the figures for consumption are most affected by the known inaccuracy of the returns of copper extracted from pyrites previous to 1876.

Causes of fluctuations in consumption, price, &c.

As to the amount of copper obtained from pyrites.

As Mr. Hunt himself draws attention to the erroneously small estimate of the amount of copper obtained from pyrites, perhaps it will not be amiss to calculate roughly what the true values probably were. According to Mr. J. A. Phillips (manager of one of the burnt-pyrites extraction works in Widnes), the copper contents of the burnt ore from imported pyrites is remarkably constant, and is about 4 per cent., which is also the percentage adopted by Mr. Hunt for 1876 and 1877. The following table shows the data in the matter and the difference in the copper product which would arise if the conjectural quantities were adopted. Pyrites, when roasted, leaves about 70 per cent. of "burnt ore," which (making an allowance for non-cupreous mineral) agrees well with the suggested corrections. In 1876 some pyrites must have been unreported, or a part of the mineral richer than usual.

About 4 per cent.

Statistics of copper extracted from burnt ore.

Copper extracted from burnt ore.

Years.	Returned consumption of burnt ore.	Estimate of copper in "Statistics."	Four per cent. of burnt ore.	Difference.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1870	200, 000	7, 500	8, 000	500
1871	225, 750	7, 900	9, 030	1, 130
1872	253, 529	8, 500	10, 141	1, 641
1873	323, 910	12, 800	12, 956	156
1874	†329, 004	9, 000	13, 160	4, 160
1875	†365, 368	9, 600	14, 614	5, 014
1876	379, 269	15, 000	15, 170	170
1877	427, 954	17, 000	17, 118	118

* Partial returns of foreign ores sold at Swansea in 1865.
† These are the values given under "Pyrites." Under "Copper," the "Mineral Statistics" gives, for 1874, 450,000 tons, and for 1875, 480,000 tons; but these quantities would be over 80 per cent. of the total import and home production of pyrites in these years, whereas pyrites loses 30 per cent. in the roasting process.

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Copper.

The metallic contents of imported ores and the consumption as given in the table would be altered as follows, by assuming the copper extracted from "burnt ore" to be 4 per cent. of the quantity of that substance returned as "consumed:"

Revised table of metallic copper in imported ores on a basis of 4 per cent.

	1870.	1871.	1872.	1873.	1874.	1875.
Metallic contents of imported ore.	27, 525	24, 801	23, 343	26, 912	32, 054	34, 497
Consumption	12, 418	7, 676	24, 851	12, 276	17, 199	28, 880

The variations here are less abrupt than in Table V.

Lead.

Lead.—The home production of lead is both large and steady, and in 1860 was just about equal to the home demand. The quantity of metal imported was one-third of the home production in 1860, but both consumption and export trade have so increased that in 1877 half as much again was imported as was produced. The business of smelting foreign lead ores has grown in a still greater proportion, the metal extracted from them in 1860 being but a few hundred tons, while in 1877 it was close upon 10,000. So steady has the lead trade been, that, although the import of metallic lead was quickened in 1872, it has since risen to far higher figures. The irregularity observable in the importation of lead ore in the years 1871 and 1872 was caused by shipments from the United States, which sent 7,589 tons of ore to England in 1871 and 2,709 tons in 1872. For the other years under discussion the importation from this country has been quite insignificant. The export of lead in 1860 was very nearly the same as the import. It has about doubled since that time, but shows considerable irregularity, owing principally to fluctuations in the demand from America and China. The consumption, too, has doubled during the past eighteen years, and its growth was scarcely checked by the crisis of 1873. In collecting the data for the table it has been necessary to assume a certain percentage of metal in the lead ore in order to reduce the quantities to comparable terms. The percentage taken was 75 (pure galena contains 86.6 per cent.), which is about 1 per cent. above the average of British ores. The few tons of litharge and white lead which appear here and there in the statistics are taken together at 80 per cent. metal. For the years 1876 and 1877 the export of British lead only is reported by Mr. Hunt. In 1874 the export of foreign lead was about 5,000 tons, and in 1875 about 3,300 tons. For the sake of completing the table approximately, I have therefore added 3,000 tons to the export of British lead for each of the last years in the table.

Fluctuations in relation of home production and importation.

Exports and imports of lead, equal.

Increased consumption.

As to estimating percentages of metal in ore for the purposes of the table.

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Zinc.

Steady in price, production, and consumption.

Zinc.—Like lead, zinc has been comparatively steady in price, production, and consumption. In both cases this steadiness is probably attributable to the extent to which they enter into the indispensable construction of buildings and the manufacture of paint. Great Britain possesses but little zinc ore, and this little is almost exclusively zinc blende, or "black jack," the most inferior of zinc ores. Consequently the country has depended chiefly for the quantity of metal consumed on supplies from Germany, Belgium, and Holland, receiving some six times as much as it produces. Large quantities of foreign ore have also been smelted in Great Britain of late years, particularly since the importation of the carbonate from Sardinia began in 1867. The supply of foreign ores has latterly decreased. The exportation of zinc is small, about 7,000 tons, or slightly more than the production. The consumption has risen very steadily to treble what it was in 1860, and is nearly ten times the production. The metallic contents of the imported ore have been ascertained from its weight and value, on the supposition that these quantities bore the same relation to one another in the foreign as in the British ore.

Britain imports six times the quantity of home production.

Consumption trebled 1860–1875.

Iron.

Included in table V for sake of comparison.

Iron.—For the sake of comparison the data with reference to iron are also introduced. As the figures for the product of Great Britain include the pig reduced from imported ore, it is not necessary to consider separately the metal thus obtained. The imported ore probably contains about $66\frac{2}{3}$ per cent. iron, and includes the "purple ore" from the burnt pyrites. Wrought-iron and steel are, of course, not taken into account in the production, because they are manufactured from pig-iron. In the exportation, on the other hand, both must be counted, as they cannot represent the same metal. The iron imported into England used to be exclusively of high quality and such as could not be made in the country, Swede ~~sm~~bars (made from manganiferous ores with charcoal), Westphalian "spiegel," and perhaps some other. The reviews now complain that Belgium is sending the cheapest iron to England for building purposes, and that Westphalian steel works are underbidding English establishments in the home market.

Pyrites.

For sulphuric acid manufacture.

Pyrites.—The extraction of sulphur and sulphurous acid for the sulphuric acid manufacture from the minerals classed under this name is said to have been suggested only some 40 years ago. The business has assumed enormous proportions of late years, as will be seen from the table. The plan of extracting small quantities of copper from the residue

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Pyrites.

Extraction of copper from the waste.

"Purple" ore.

Prof. T. Thomson.

Henderson & Longmaid.

Illustration of value of modern scientific teachings.

after expulsion of the 45 per cent. or so* of sulphur contained in the mineral seems to have been first carried into operation on a large scale in 1867. In that year 500 tons of copper is accredited to this source in the "Mineral Statistics." As has been already mentioned, the residue after the extraction of the copper is employed under the name of "purple ore" in iron-smelting. This is a proof of the perfection of the preceding processes, for, as is well known, sulphur and copper are fatal to the value of iron ore when present in more than exceedingly minute proportions. Indeed, the process may be considered as one of the most perfect in the arts, all the essential ingredients of the mineral being profitably extracted and thoroughly separated. Prof. Thomas Thomson, of Glasgow, a famous chemist in his day, is credited by Muspratt with the initiation of the manufacture of sulphuric acid from pyrites in 1835, when the King of Sicily placed a heavy duty upon exported sulphur. Henderson and Longmaid, English chemists, worked out the copper extraction process much later. The treatment of pyrites is, therefore, an achievement of modern science. Both as an instance of the relations existing between science and industry and as a matter of growing commercial importance, it may be interesting to dwell for a moment on the financial results of this process, results which ought to go some way towards vindicating the "practical" character of modern scientific teachings.

The pyrites industry.

Results of the treatment of cupreous pyrites in 1877.

Pyrites imported, 679,312 tons, yielding 45 per cent. sulphur, or 305,690 tons, equal to sulphuric acid (worth 1*d.* per lb., or £9⅓ per ton), 917,071 tons	£8,559,024
Copper extracted, 17,000 tons, worth at £74 12*s.* 6*d.* (price of tough cake)	1,268,625
Purple ore, smelted, 415,000 tons, containing 65 per cent. iron, or 260,750 tons pig, worth at £2 5*s.* 6*d.* (price Cleveland)	613,670
Total	10,441,319
	$50,144,810

This is a minimum estimate, for a large proportion of the small percentage of silver contained in the pyrites is extracted, as well as some of the gold, by M. Claudet's process.

Silver.

Silver.—The data relating to the exportation, importation,

*It has been stated under "Copper" that the burnt ore amounts to about 70 per cent. of the pyrites. This is not inconsistent with the loss of 45 per cent. of sulphur, because the sulphur is replaced by oxygen. A gross loss of 30 per cent. by weight answers to a loss of 48 per cent. of sulphur. A little sulphur remains in the burnt ore.

GREAT BRITAIN.

Silver.

The great eastern drain for silver.

Researches of the British and American Silver Commissions.

British source of metallic silver.

Foreign ores smelted in Britain.

Mode of estimating value of ores.

and consumption of silver are imperfect and unsatisfactory. The movements of this metal are so largely controlled by the exigencies of Eastern commerce and by the financial policy of the great commercial countries, that their discussion is only in a very subordinate degree an affair appertaining to the mineral industry. During certain years vastly more silver has been exported from Great Britain than has been imported. In other years enormous quantities have been retained in the country. The facts bearing upon this point have been elicited by the British and the American Silver Commissions. A single feature of the subject appears to me to have received less attention than it was entitled to, viz, the extent to which foreign argentiferous ores are treated in Great Britain. This point is not covered by the "Mineral Statistics," and I know of no source whence absolutely trustworthy data are to be obtained. In the absence of such, I have prepared a rough approximation, which may serve to give those interested at least some idea of the extent to which silver is separated in the United Kingdom.

Besides the desilverization of argentiferous British lead, metallic silver is derived from the following sources: The treatment of silver ores entered at the custom-house as such; the desilverization of foreign lead sent to England largely for that purpose; copper ore and regulus and cupreous pyrites.

Considerable quantities of silver ore are annually sent to Britain, mainly to Swansea, and the declared value of these ores is regularly noted in the "Mineral Statistics." The number of tons is also given up to the year 1873. The silver contents of these ores are not, however, inferable from their gross weight and value, because a higher price per ounce is paid for the silver in high-grade ores than for that in poor ores. A comparison of the average price per ton with a price list would consequently lead to too high a valuation of the number of ounces of silver imported.* The error which would be incurred by such a procedure can be obviated by assuming a sufficiently high rate in calculating the contents from the value. Five pence per ounce would certainly be a small mean charge for the separation of silver from its ores.†

* The maximum price per ounce is subject to a deduction which is inversely proportional to the number of ounces per ton. Hence the mean *contents* of two lots correspond to a lower rate than is actually paid. Were this relation reversed it would pay to mix poor ores with rich ones, an absurd supposition.

† The average value of the imported silver ores for three of the years under discussion in which the tonnage is given is just £100.

GREAT BRITAIN.

Silver.

This is about the difference between the value of standard silver and fine silver. In the table given below the amount of silver obtained from silver ores has been estimated by dividing the declared value of the silver ores imported during that year by the average price of standard silver (0.925 fine) for the same period.

Silver in lead.

It may be assumed that all the lead imported into Great Britain is desilverized there, because, on account of the organization of industry and the abundance of fuel, the separation can be more economically effected there than, for instance, in Spain or Greece, the principal sources of supply. It is probably fair to assume that the imported lead contains at least 25 ounces of silver per ton.*

Silver in cupreous pyrites.

The cupreous pyrites treated in England contains a small quantity of silver per ton, which is at present recovered, at least in part, by Claudet's beautiful process. According to Mr. Phillips, ordinary pyrites yields in this way 0.65 ounces silver per ton. The process was, however, only introduced in 1870. It does not seem excessive to allow ½ ounce per ton since 1874 from this source.

Claudet.

Silver from copper ores.

The amount of silver derived from copper ores other than pyrites I have no means of estimating. Only certain copper ores are apt to contain silver, but such, either raw or in the form of regulus, would naturally be preferred for shipment. I will assume it at 12½ ounces per ton of copper produced.†

Silver produced in Britain from imported materials.

Estimate of silver produced in Great Britain from imported materials, in ounces.

Years.	From silver ores.	From lead.	From cupreous pyrites.	From other copper ores.	Total in round numbers.
1860	1,489,200	569,475	....	171,438	2,230,000
1865	1,503,000	979,275	....	299,025	2,780,000
1870	1,187,800	1,732,525	....	337,813	3,260,000
1871	3,784,300	2,021,750	....	295,888	6,100,000
1872	8,707,000	2,030,050	....	271,275	11,010,000
1873	4,134,100	1,796,100	....	334,450	6,260,000
1874	3,166,600	1,839,950	249,319	348,675	5,600,050
1875	2,300,300	2,227,725	268,778	368,538	5,170,000
1876	2,273,900	2,252,975	252,376	452,388	5,230,000
1877	2,463,200	2,602,700	339,656	669,775	6,080,000

* Italian lead averages 25 ounces, according to Phillips. Greek lead averages in the neighborhood of 20 ounces, according to Percy. Spanish lead, according to a circular of Luce and Rozan, 44 ounces. French lead is richer. English lead averages about 10 ounces.

† Cupreous pyrites contains 2.8 per cent. copper. If ½ ounce per ton pyrites is recovered, then 18 ounces of silver are obtained for each ton of copper derived from this source.

GREAT BRITAIN.

The items are given in the table as they result from calculation, but are to be viewed, of course, only as, perhaps distant, approximations. It is, however, probably fair to say that the amount of silver produced in Great Britain from foreign ores has been, since 1870, excepting in 1872, from 5 to 7 millions of ounces yearly, or, say, from 6½ to 9 millions of dollars. Sir Hector Hay, in his testimony before the British Silver Commission, estimated this quantity at £1,000,000; Mr. E. Seyd at considerably less.

Estimated British production of silver.

Consumption of silver.

The consumption of silver in Great Britain was estimated at about the value of 5½ millions of dollars, but, it is said, without taking into consideration the quantity separated either from foreign or native material.

Coal.

Coal.—Rather more than one-tenth of the output of coal in Great Britain is exported, and this relation has been pretty constantly observed throughout the period under discussion. Both export and consumption were merely disturbed by the crisis of five years back, and were far greater in 1877 than in 1872–'73.

Export one-tenth of the output.

Mr. Hunt has gathered some exceedingly interesting data concerning the uses to which coal is put in Great Britain for the years 1871–'72–'73. The table for 1873 is here substantially reproduced. In a second table I have calculated the proportion of fuel consumed for various purposes from Mr. Hunt's table. It will be seen from these tables that the mining industry consumes almost half of the coal used in England for industrial purposes and 40 per cent. of the total amount burned.

The employment of coal.

The uses for which the coal raised in Great Britain was employed in 1873.

	Tons.
Tin smelting and refining	42,422
Copper smelting and refining	360,195
Lead and silver smelting and refining	179,540
Zinc smelting and refining	181,450
Iron smelting and refining	35,119,709
Mines and collieries	9,500,000
Total mining and metallurgy	45,383,316
Railways	3,790,000
Steam navigation	3,650,000
Steam power in factories	27,550,000
Water works	650,000
Gas manufacture	6,560,000
Pottery, bricks, lime, glass, etc	3,450,000
Chemical works and sundry	3,217,229
Household consumption	20,050,000
Exportation *	12,712,222
Total	127,012,767

* The quantity of coal exported in 1873 is given at a slightly lower figure in later numbers of the "Statistics."

Relative quantities of coal employed for various purposes in Great Britain in 1873.

GREAT BRITAIN.

Relative quantities of coal employed for various purposes.

	Of the coal raised.	Of the coal not exported.	Of the coal industrially consumed.
	Per cent.	*Per cent.*	*Per cent.*
In mining and metallurgical industries	35.74	39.70	48.15
On railways	2.98	3.32	4.02
In steam navigation	2.87	3.19	3.88
For steam power in factories	21.69	24.10	29.23
For steam power at water works	.51	.57	.69
For manufacture of gas	5.17	5.74	6.96
In potteres, glass works, etc	2.72	3.02	3.66
In chemical factories and sundry	2.53	2.82	3.41
For household consumption	15.79	17.54	....
Quantity exported	10.00	....	....
	100.00	100.00	100.00

Estimate of proportion of coal employed in mining and smelting.

What the relative proportions in other countries are it might be difficult to ascertain, but it is probably safe to say that fully one-third of all the coal raised is consumed in mining and smelting operations. The economy of fuel in iron-smelting has of late years made considerable advances under the stimulus of high prices of coal and low prices for iron. In 1870, Mr. Hunt ascertained the consumption of coal per ton of pig-iron to be three tons. In 1877 the consumption in the manufacture of pig had fallen to 2⅓ tons. The manner in which this economy has been effected, the more judicious dimensions selected for blast furnaces, the improved hot-blast stoves, and the general study into the science of iron-smelting under the efficient leadership of Mr. Bell will doubtless be discussed in the special report on iron and steel.

Foreign sources of supply and points of destination of ores and metals handled in Great Britain.

Sources of supply and destination of ores and metals.

England carries on not only a larger but a much more extended trade in metals and ores than any other country. In 1877 foreign ores were imported at 62 ports in the United Kingdom, and it would be difficult to find a mining district in the world which does not send ore or metal to England, or a market at which no metal is received from the United Kingdom. An exhaustive discussion of this traffic would be scarcely possible under the most favorable circumstances, and no attempt will be made here to do more than give a few characteristic data and to point out a few salient features of the subject. The tables are especially recommended to those who feel any interest in the matter, as small infor-

England's worldwide commercial intercourse.

Tables VI to XI, pages 221-225.

GREAT BRITAIN.

mation and a trifling amount of patience will serve to elicit many interesting facts concerning the development of human industry and the interdependence of human pursuits from them.

Tin.

Tin.—Little tin ore has been imported into England, except for a couple of years after the opening of the Australian tin mines. Chili and Peru send a small amount with some regularity, and Holland and the Straits now and then a ton. This ore is probably brought to Europe as ballast by trading vessels which have been cruising among the islands of the Malayan Archipelago. The Cape also sends a trifling amount from time to time. Even France, Spain, Portugal, and other countries have occasionally sent a few tons. The fact is that tin-stone, like cinnabar, is not a very rare mineral, though there are but few localities where it occurs in paying quantities. It may be a surprise to some to see that Australia sent tin-stone in relatively considerable quantities to England long before the mines which have grown so important were discovered. The contents of the ore recorded in the table may probably be taken at about 70 per cent. metallic tin. The principal foreign sources of metallic tin are Australia and the Straits, tin from the Dutch Indies going principally to Continental markets. It is interesting to observe from the table how rapidly the Australians mastered the business of tin-smelting, the exports of ore having fallen within a couple of years of the great discoveries to a lower point than that at which they were before, and the amount of metal sent "home" having more than proportionately increased. The imports of tin from Australia are given as per parliamentary returns. In later volumes of the "Statistics," however, Mr. Hunt appears to adopt figures at first given as unofficial, and which are as follows:

Table VI (page 221).

Sources of tin ore.

Australia and Strait-settlements the principal sources of metallic tin.

Imports of Australian tin.

	Tons.
1872	150
1873	2,990
1874	5,800
1875	7,210

The imports from the Straits show a rapid increase. This tin appears to be smelted by natives and Chinese on the Malayan Peninsula, from stream tin, in rude hearths, but the writer has been unable to find any statement of the conditions. The principal consumers of tin are, as might have been expected, France, Germany, and the United States, and the consumption has grown enormously with the fall of price. Germany produces some tin for home consumption, and, of course, Dutch tin is consumed more or less in all countries.

Fall in price and great increase in consumption.

GREAT BRITAIN.

It will be observed that the table contains no data for 1876 and 1877, and the same will be found to be the case for several of the succeeding tables as well. For these years neither the "Mineral Statistics" nor the "Economist" gives sufficiently detailed accounts of the imports and exports to make the compilation of the data possible, a fact which I greatly regret.

Tin.

Copper.

Table VII (page 222).

Copper.—By no means all of the sources of supply are given in the table, many other countries sending small lots of ore and metal; nor are the copper contents of cupreous pyrites taken into account. Chili, Australia, and the Cape of Good Hope are the principal countries from which Great Britain imports copper and its ores, and of these Chili is much the most important. It will be noticed with interest that both Australia and Chili are every year sending a greater proportion of metallic copper, and a smaller one of ore, indicating the advance of the metallurgical industries of those countries. The Cape, on the other hand, while sending far more ore to England than any other country except Chili, sends no metallic copper and only an insignificant quantity of regulus. The metallic contents of the ore and regulus are higher than formerly, apparently because most of the regulus now imported is concentrated at the mines. The average copper contents of ore and regulus together were 18 per cent. in 1873, in which year about one-third of the total importation was regulus, while in 1877, less than one-fourth of the total being regulus, the average copper contents were about 24 per cent.

Sources of copper and copper ores.

Increase in Australian and Chilian imports of metallic copper.

Increased richness of the copper imports.

All the principal countries of Europe and British India are large consumers of copper from England, though several of them are large producers. The United States, on the other hand, has bought only insignificant amounts of this metal from England, except in the years of inflation, nor does this country send any noticeable quantity of ore or metal to England, although Lake Superior copper has the preference for telegraphic purposes.

Consumers of copper from England.

Lead.

Table VIII (page 223).

Lead.—Comparatively little lead ore is imported into England, and that chiefly from Italy, while Spain sends enormous and increasing quantities of the metal. Greece sent large amounts of metal for a time, but the import from that country fell off suddenly in 1874. Much the most important customer of the English lead merchants is China, which in 1877 took about as much as all the other principal countries together. France, Germany, Russia, and the United States are of course large producers of lead. The quantity bought by the United States has fluctuated greatly, though on the

Sources of lead and lead ore.

China the principal customer of England.

GREAT BRITAIN.

Lead.

whole it has declined since 1870, when it was nearly 13,000 tons. In 1875 we bought of England only 485 tons, but the importation had risen again in 1877 to nearly 3,000 tons. The figures for exportation are the corrected values given in the "Mineral Statistics" for years subsequent to those to which the numbers refer. I am inclined to the opinion that for the years 1876 and 1877 only the British lead is reported, although no statement to that effect is made. The exportation of foreign lead is small, being less than 10 per cent. of the whole in 1875. Russia in that year took the largest proportion of foreign lead, about one-eighth to seven-eighths of British production.

Zinc.

Table IX (page 224).

Spanish and Sardinian ores.

Zinc.—Large quantities of zinc ore of foreign production are smelted at Swansea. They come chiefly from Spain and Sardinia, especially the latter, and are mainly carbonate. The importation of zinc ore from Sardinia began in 1867, and was over 30,000 tons in 1870, but little more than half this quantity in 1875, and still smaller since, for in 1876 the total quantity of zinc ore imported fell short of 12,000 tons. In 1877 the total import rose again to over 19,000 tons. The imports of ore from other countries are insignificant. The metallic contents of the imported ore, as calculated from its value, are in the neighborhood of 40 per cent. Pure carbonate contains 52 per cent.*

Importations of Belgian and Silesian metallic zinc.

Belgium and Silesia are the two most important zinc-producing districts in Europe, and from them England imports the greatest quantity of crude and manufactured (mostly rolled) metal. England also imports much zinc from Holland, a country which produces none. I have failed to discover how this happens.

Great Britain exports insignificant quantities of zinc, except to its own possessions in India.

Iron.

Iron.—No sufficient data for ascertaining the distribution of iron exported from England have been found.

Pyrites.

Table X (page 224).

Pyrites.—Spain, Portugal, and Norway furnish essentially all the pyrites imported into England. In the beginning of the period under discussion Portugal was the main source of supply, but the Spanish mines have been developed with great steadiness and rapidity, and in 1876 furnished more than four-fifths of the total supply.

Coal.

Table XI (page 225).

Coal.—Excepting Belgium, all the principal countries of Europe are large consumers of British coal, France and

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* The zinc contents of Sardinian ore probably fall a little short of 40 per cent., a higher price being paid for the superior quality of the ore. According to a statement of Mr. Vivian to Mr. J. A. Phillips, the Sardinian product averages about 33 per cent.

Destination of British export.

Germany leading. The large amount taken by Chili is no doubt sent out, with manufactured goods, in ships which come home loaded with copper, etc. The coal sent to the United States is probably for gas-making purposes. The high prices of 1873 checked the exportation to most countries, but the general tendency is to a decided increase; Germany, however, has never since imported so much coal from England as in 1871, while France takes about half as much again as at that period. British India affords a large and constantly increasing market for English coal, notwith standing the immense distance.

GREAT BRITAIN.

London prices of metals 1860–1877.

TABLE I.—*Average price of metals and coal per ton (except silver) in London.*

		1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Pig-iron at works..	Cleveland	2 14 11	2 9 6	2 9 6	2 9 6	5 4 6	5 15 0	3 15 6	3 0 0	2 13 0	2 5 6
	Scotch	2 14 0	2 19 0	2 19 3	2 2 2	5 10 0	6 10 6	4 19 0	3 4 0	2 18 6	2 14 4
	Welsh	3 16 0	4 15 6	4 0 0	4 6 7	6 12 0	6 10 6	5 7 6	4 4 11	4 2 6	3 17 6
Tin	English	136 3 1	96 15 0	127 8 6	137 10 0	152 15 0	133 7 0	108 8 0	90 2 0	79 10 2	73 3 6
	Banca	136 13 10	95 0 0	125 0 0	135 6 0	153 5 0	134 14 6	103 0 0	90 0 0	73 12 11	71 7 0
Copper	Best selected	109 13 10	94 7 0	72 13 0	77 10 0	104 5 0	95 18 0	89 12 0	90 0 0	83 6 2	75 16 0
	Tough cake	100 13 10	91 15 0	70 11 0	75 10 0	97 15 0	93 13 6	84 0 0	88 9 0	81 19 6	74 12 6
Lead	English pig	22 6 3	20 2 0	18 13 0	18 4 0	20 0 0	23 6 0	22 2 0	22 9 4	21 13 10	20 11 3
	English (W. B.)	....	21 6 0	19 12 6	19 17 6	21 14 0	24 7 8	23 6 0	23 6 6	23 1 9	21 7 0
Zinc, English		20 11 0	20 12 0	18 16 6	18 11 6	22 15 0	26 15 0	23 6 6	24 5 0	23 18 4	21 15 0
Silver (per ounce)		61 11/16	61 1/16	60 9/16	60 1/2	60 5/16	59 1/4	58 5/16	56 7/8	52 3/4	54 13/16
Coal	Cheapest	13 11	14 0	16 0	16 10	1 3 0	1 9 9	1 2 11	1 0 0	18 0	16 6
	Dearest	1 2 9	18 9	17 0	18 10	1 4 6	1 12 0	1 4 11	1 3 0	1 0 5	18 6

GREAT BRITAIN.

London prices of metals 1860–1877, in American money.

TABLE II.—*Average price of metals and coal per ton (except silver) in London.*

		1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Pig-iron at works	Cleveland	$13 34	$12 03	$12 03	$12 03	$25 39	$27 95	$18 35	$14 58	$12 88	$11 06
	Scotch	13 12	14 34	14 40	15 11	26 73	31 71	24 06	15 55	14 09	13 20
	Welsh	18 47	23 21	19 44	21 04	32 08	31 71	26 12	20 63	20 05	18 83
Tin	English	661 71	470 21	619 28	668 25	742 37	648 08	526 82	437 89	386 41	355 63
	Banca	664 32	461 70	607 50	657 56	744 80	654 76	500 58	437 40	357 92	346 76
Copper	Best selected	533 10	458 54	353 08	376 65	506 66	466 07	435 46	437 40	404 88	368 39
	Tough cake	518 52	445 91	342 87	366 90	475 07	455 26	408 24	429 87	398 40	362 68
Lead	English pig	108 44	97 69	90 64	88 45	97 20	113 24	107 41	109 19	105 42	99 93
	English (W. B.)	....	103 52	95 38	96 59	105 46	118 50	113 24	113 36	112 20	103 76
Zinc, English bar		99 87	111 11	91 49	90 27	110 57	130 01	113 36	117 86	116 23	105 71
Silver (per ounce*)		1 24⅜	1 23⅛	1 22½	1 22½	1 22⅛	1 20	1 18⅛	1 15⅛	1 06⅞	1 11
Coal	Cheapest	3 38	3 40	3 89	4 09	5 59	7 23	5 57	4 86	4 37	4 01
	Dearest	5 53	4 55	4 13	4 57	5 95	7 78	6 05	5 59	4 96	4 49

*English standard, 0.925 fine.

GREAT BRITAIN.

Production of metals and minerals in the United Kingdom.

Weight.

TABLE III.—*Weight of metals and minerals produced in the United Kingdom.*

Metal or mineral.	In the years									
	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Gold .... ounces		1, 664	191				385	579	293	143
Pig-iron .... tons	3, 826, 752	4, 819, 254	5, 963, 515	6, 627, 179	6, 741, 929	6, 566, 451	5, 991, 408	6, 365, 462	6, 555, 997	6, 608, 664
Copper .... do	15, 968	11, 888	7, 175	6, 280	5, 703	5, 240	4, 981	4, 322	4, 694	4, 486
Tin .... do	6, 656	9, 038	10, 200	11, 320	9, 560	9, 972	9, 942	9, 614	8, 500	9, 500
Lead .... do	63, 225	67, 251	73, 420	69, 037	60, 420	54, 235	58, 777	57, 435	58, 667	61, 403
Silver .... ounces	549, 090	724, 856	784, 562	761, 490	628, 920	*531, 077	509, 277	487, 358	483, 422	501, 435
Zinc .... tons	4, 357	4, 040	3, 936	4, 966	5, 191	4, 471	4, 470	6, 713	6, 641	†6, 281
Clay .... do	508, 666	1, 125, 924	1, 200, 000	1, 255, 000	1, 200, 000	1, 785, 000	2, 436, 912	3, 008, 444	3, 971, 123	2, 961, 155
Salt .... do	1, 570, 972	921, 826	1, 489, 450	1, 505, 725	1, 309, 497	1, 785, 000	2, 306, 567	2, 316, 644	2, 273, 256	2, 735, 001
Coal .... do	80, 042, 698	98, 150, 587	110, 431, 192	117, 352, 028	123, 497, 316	127, 016, 747	125, 043, 257	131, 867, 105	133, 344, 766	134, 610, 763
Pyrites .... do	135, 669	114, 195	58, 429	61, 973	65, 916	58, 924	56, 208	48, 036	48, 810	43, 949

* In the "Mineral Statistics" for 1873 the amount of silver given in the introduction is 537,707 ounces. On p. 40 it is given at 524,307 ounces. The number here stated appears on p. 51 and is retained in subsequent reports.

† This is the number given in the introduction to the "Mineral Statistics," and corresponds better to the average market price than that given on p. 38.

GREAT BRITAIN.

Production of metals and minerals in the United Kingdom.

Value.

TABLE IV.—*Value of metals and minerals produced in the United Kingdom.*

Metal or mineral.	IN THE YEARS									
	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Gold	....	£5, 824	£750	....	....	....	£1, 540	£2, 105	£1, 138	£656
Pig-iron	£12, 703, 950	11, 774, 220	14, 908, 787	£16, 667, 947	£18, 540, 304	£18, 057, 739	16, 476, 372	15, 645, 774	16, 062, 192	16, 191, 236
Copper	1, 706, 261	1, 134, 664	551, 309	475, 143	583, 232	502, 822	447, 891	388, 984	392, 300	340, 067
Tin	871, 382	971, 273	1, 299, 505	1. 498, 750	1, 459, 990	1, 329, 766	1, 077, 712	866, 266	675, 750	695, 162
Lead	1, 417, 415	1, 433, 161	1, 452, 715	1, 251, 815	1, 209, 115	1, 263, 375	1, 298, 463	1, 290, 373	1, 270, 415	1, 262, 600
Silver	151, 173	199, 335	196, 140	190, 372	157, 230	131, 077	127, 319	115, 747	106, 222	114, 877
Zinc	89, 536	104, 810	74, 096	92, 743	118, 076	120, 099	106, 773	162, 790	158, 011	136, 612
Other metals	....	150, 000	3, 500	3, 000	2, 500	5, 000	3, 000	4, 707	2, 790	1, 750
Total metals	16, 939, 717	15, 773, 287	18, 486, 802	20, 179, 770	22, 070, 447	21, 409, 878	19, 539, 070	18, 476, 746	18, 668, 818	18, 742, 960
Coal	20, 010, 674	24, 537, 646	27, 607, 798	35, 205, 608	46, 311, 143	47, 631, 280	45, 849, 194	46, 163, 486	46, 670, 663	47, 113, 767
Clay	221, 150	373, 916	450, 000	475, 000	450, 000	656, 300	780, 159	753, 957	744, 224	592, 231
Salt	589, 114	440, 000	744, 725	752, 862	654, 748	892, 500	1, 153, 233	1, 158, 322	1, 136, 628	1, 504, 250
Other minerals	*170, 927	620, 580	656, 975	708, 653	707, 078	133, 034	512, 657	935, 177	1, 006, 515	328, 199
Total metals and minerals	37, 930, 982	41, 745, 429	47, 966, 300	57, 321, 893	70, 193, 416	70, 722, 992	67, 834, 313	67, 487, 688	68, 226, 853	68, 281, 406

*Including metals.

Importation, exportation, consumption of metals and minerals.

TABLE V.—*Importation, exportation, and consumption of metals and minerals.—Data for the United Kingdom.*

	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Iron:										
Importation, wrought and steel	57, 849	58, 258	113, 967	104, 409	130, 047	117, 196	134, 240	157, 169	163, 774	181, 020
Exportation	1, 441, 667	1, 615, 189	2, 825, 575	3, 169, 219	3, 382, 762	2, 957, 813	2, 487, 522	2, 457, 306	2, 265, 013	2, 390, 551
Consumption	2, 443, 534	3, 262, 323	3, 251, 907	3, 562, 369	3, 489, 214	3, 725, 834	3, 638, 126	4, 065, 325	4, 454, 758	4, 399, 133
Tin:										
Imported metal	2, 911	5, 699	4, 715	8, 583	8, 342	7, 791	9, 218	16, 788	15, 222	13, 762
Metal imported in the ore	438	409	219	336	553	3, 775	3, 500	246	184	190
Exportation	3, 269	7, 191	6, 207	7, 770	8, 126	7, 201	10, 113	9, 267	10, 247	10, 005
Consumption	6, 736	7, 955	8, 927	12, 469	10, 334	14, 337	12, 547	17, 381	13, 659	13, 447
Copper:										
Imported metal	13, 142	23, 137	30, 724	33, 228	49, 000	35, 840	39, 906	41, 931	39, 145	39, 743
Metal imported in the ore	13, 715	23, 922	27, 025	23, 671	21, 702	23, 756	27, 894	29, 483	36, 191	53, 582
Exportation	26, 117	41, 398	53, 006	56, 633	53, 195	55, 716	59, 742	51, 870	52, 468	54, 088
Consumption	16, 708	17, 549	11, 918	6, 546	23, 210	12, 120	13, 039	23, 866	27, 562	43, 723
Lead:										
Imported metal	22, 171	34, 983	60, 064	65, 225	70, 282	63, 078	62, 303	80, 172	80, 719	94, 412
Metal imported in the ore	608	4, 188	9, 237	15, 645	10, 920	8, 766	11, 295	8, 937	9, 400	9, 696
Exportation	23, 797	32, 788	61, 512	45, 649	46, 831	33, 376	42, 049	38, 900	39, 006	45, 411
Consumption	62, 207	73, 634	81, 209	104, 258	94, 791	92, 703	90, 326	107, 644	109, 780	120, 100
Zinc:										
Imported metal	24, 416	32, 191	31, 103	29, 694	27, 118	32, 501	34, 838	37, 870	49, 185	51, 196
Metal imported in the ore	1, 440	1, 547	18, 020	11, 520	9, 785	8, 939	8, 117	7, 470	4, 171	7, 124
Exportation	9, 483	8, 244	10, 687	8, 807	7, 273	4, 486	5, 536	6, 528	7, 000	7, 300
Consumption	20, 730	29, 534	42, 372	37, 373	34, 821	41, 425	41, 889	45, 525	52, 997	57, 301
Pyrites:										
Importation	85, 271	193, 626	411, 512	454, 542	517, 626	520, 347	498, 637	537, 555	504, 752	679, 312
Consumption	220, 940	307, 821	469, 940	516, 515	583, 542	579, 271	554, 845	585, 591	553, 562	723, 261
Coal:										
Exportation	7, 321, 832	9, 170, 477	11, 702, 649	12, 747, 989	13, 198, 494	12, 617, 566	13, 927, 205	14, 544, 916	16, 299, 077	15, 420, 050
Consumption	72, 720, 866	88, 980, 110	98, 728, 543	104, 604, 039	110, 298, 822	114, 399, 181	111, 116, 052	117, 322, 189	117, 045, 689	119, 190, 713

GREAT BRITAIN.

Tin.

Sources of supply and points of destination.

TABLE VI.—*Tin: Principal sources of supply and points of destination of metal and ore handled in England.*

IMPORT OF ORE.

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.
Australia	120	222	164	192	812	4, 726	3, 656	60
Chili	......	79	105	187	18	157	28	....
Holland	....	1	....	7	43	1	1	1
Peru	516	307	70	150	101	671	535	296
Straits	6	14	....	....	....	1	1	26

IMPORT OF METAL.

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.
Australia	....	9	....	10	50	494	4, 024	7, 213
Chili	2	13	150	209	79	114	43	58
Holland	517	510	2, 060	1, 866	298	1, 770	452	467
Peru	65	17	16	284	448	387	367	202
Straits	2, 289	4, 932	2, 335	5, 456	6, 095	4, 812	4, 177	8, 566

EXPORT OF METAL.

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.
Russia	519	480	659	681	625	957	780	933
Turkey	270	221	243	328	477	383	451	362
France	1, 173	1, 627	1, 455	2, 367	2, 480	1, 556	2, 124	2, 420
Germany	155	528	368	739	978	718	1, 150	1, 371
United States	194	2, 943	2, 079	1, 699	1, 462	1, 720	3, 489	1, 832

GREAT BRITAIN.

Copper.

Sources of supply and points of destination.

TABLE VII.—*Copper: Principal sources of supply and points of destination of metal and ore handled in England.*

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
IMPORT OF ORE (INCLUDING REGULUS).										
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Australia	8, 666	11, 261	14, 817	6, 456	1, 253	1, 778	589	329	....	....
British North America	126	438	7, 069	3, 970	5, 624	6, 845	5, 069	9, 069	....	....
Bolivia	7, 153	4, 965	4, 548	4, 479	3, 355	3, 026	5, 401	3, 888	....	....
Chili	48, 000	58, 314	43, 350	30, 081	24, 796	35, 509	29, 977	34, 495	24, 259	24, 980
Cuba	16, 605	16, 820	889	201	46	....	....	408	....	....
South Africa	3, 512	4, 156	6, 926	6, 414	12, 678	11, 127	12, 789	12, 484	*14, 059	*14, 060
Spain	4, 704	3, 254	9, 807	8, 590	7, 233	6, 137	5, 513	5, 768	....	....
IMPORT OF METAL.										
Australia	1, 846	2, 135	4, 594	7, 447	11, 681	10, 616	10, 350	11, 409	9, 928	10, 947
Chili	7, 266	16, 469	22, 051	20, 773	27, 534	20, 332	21, 724	25, 212	26, 170	25, 754
France†	1, 011	379	1, 297	652	1, 503	231	463	734	....	....
EXPORT OF COPPER.										
British India	8, 910	10, 422	12, 352	9, 244	5, 217	5, 165	8, 002	9, 864	....	....
France	5, 078	9, 821	10, 131	8, 849	6, 200	12, 584	14, 276	6, 791	....	....
Germany	1, 398	3, 026	5, 220	8, 216	8, 473	6, 273	7, 775	7, 734	....	....
Holland	1, 689	4, 228	4, 899	6, 434	13, 353	6, 852	7, 430	6, 570	....	....
Italy	1, 228	1, 865	2, 111	2, 002	17, 090	1, 888	2, 142	2, 575	....	....
Russia	42	817	3, 725	5, 721	17, 095	3, 129	4, 599	3, 927	....	....
United States	622	503	115	143	4, 325	3, 705	811	271	....	....

* Ore only. The amount of regulus imported from South Africa is small; in 1875 it was 34 tons.
† Not including copper manufactures. The value only is given and includes engraved plates. Calculation of the weight from the value would be very uncertain.

GREAT BRITAIN.

Lead.

Sources of supply and points of destination of exports.

TABLE VIII.—*Lead: Principal sources of supply and points of destination of metal and ore handled in England.*

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
IMPORT OF ORE.										
Australia	269	710	699	1,033	629	659	1,623	2,108	....	....
France	....	23	839	964	1,311	1,787	1,235	1,587	....	....
Italy	321	4,197	7,881	7,768	5,820	6,428	8,144	5,712	....	....
Portugal	107	147	1,157	1,245	871	329	766	1,252	....	....
IMPORT OF METAL.										
Belgium	1,245	2,240	236	95	256	2,277	1,951	3,053	....	....
Greece	....	....	9,567	8,800	9,514	7,133	1,411	1,722	....	....
Holland	1,205	2,446	3,171	2,906	3,455	2,690	1,875	1,261	....	....
Portugal	238	30	1,022	1,670	2,250	2,285	2,829	2,196	....	....
Spain	17,737	27,474	42,558	49,455	53,484	47,451	52,560	69,957	....	....
EXPORT OF METAL.										
British India	1,317	829	3,038	2,953	2,834	1,177	1,743	1,843	1,883	2,459
China	5,171	2,191	12,495	9,548	7,082	3,935	8,963	9,781	10,348	15,332
France	1,116	4,552	3,326	2,463	2,022	1,494	2,982	2,834	1,792	1,501
Germany	675	360	3,300	3,959	5,161	3,647	2,616	3,056	1,286	1,404
Russia	4,812	1,867	7,460	5,111	8,481	8,063	11,435	9,993	9,055	7,490
United States	4,155	8,227	12,556	11,151	8,353	2,919	3,421	485	1,314	2,906

GREAT BRITAIN.

Zinc.

Sources of supply and points of destination.

TABLE IX.—*Zinc: Principal sources of supply and points of destination of metal and ore handled in England.*

IMPORT OF ORE.

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
France	796	1, 519	2, 246	1, 058	843	1, 4 6	710	......
Italy	....	....	31, 417	20, 761	25, 266	21, 693	14, 734	17, 295
Norway and Sweden	138	75	1, 444	945	1, 439	1, 114	328	55
Spain	3, 434	3, 545	9, 162	6, 086	5, 010	5, 129	5, 201	3, 500

IMPORT OF SPELTER AND MANUFACTURED ZINC.

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.
Belgium	3, 431	8, 240	16, 786	17, 175	10, 329	8, 781	6, 310	13, 681
France	363	427	432	389	1, 965	3, 298	1, 375	2, 247
Germany	18, 942	18, 354	8, 492	5, 879	7, 115	11, 522	11, 882	11, 468
Holland	1, 593	3, 886	4, 632	6, 027	7, 433	8, 514	8, 890	10, 011

EXPORT OF SPELTER AND MANUFACTURED ZINC.

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.
Australia	232	526	424	242	403	505	782	962
British America	116	130	165	242	195	102	306	372
British India	5, 988	3, 095	5, 991	5, 998	4, 962	1, 906	2, 108	2, 975
France	1, 527	2, 008	1, 912	597	59	541	564	793
Turkey	63	240	235	190	211	280	25	....
United States	....	1, 310	448	253	419	39	185	111

Pyrites.

Sources of supply.

TABLE X.—*Pyrites: Principal sources of supply of the mineral treated in England.*

Countries.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Spain	16, 393	150, 996	242, 163	257, 429	246, 692	294, 117	344, 019	419, 068
Portugal	137, 787	174, 459	120, 573	180, 329	199, 559	162, 569	165, 433	56, 579
Norway	22, 229	67, 467	74, 416	71, 665	67, 462	41, 044	21, 820	7, 688
Holland	14, 727	14, 914	12, 809	5, 682	....	....	....	....

GREAT BRITAIN.

Coal.

Points of destination of exports.

TABLE XI.—*Coal and coke: Principal points of destination of fuel exported from England.*

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
British India	298, 102	....	426, 619	573, 261	528, 806	533, 336	644, 607	603, 159	759, 855	895, 963
Chili	49, 924	....	81, 507	105, 349	226, 455	135, 906	210, 753	240, 605	....	160, 460
Denmark	418, 356	618, 233	704, 537	658, 701	641, 508	592, 789	662, 289	749, 399	779, 822	765, 608
Egypt	111, 997	....	408, 405	455, 469	509, 770	526, 865	617, 578	530, 252	545, 337	520, 476
France	1, 364, 872	1, 562, 627	2, 066, 444	1, 977, 198	2, 156, 041	2, 402, 177	2, 281, 409	2, 610, 865	3, 250, 564	3, 010, 143
Germany	1, 113, 278	1, 255, 301	1, 603, 249	2, 396, 811	2, 113, 564	1, 668, 680	2, 056, 881	2, 172, 319	2, 278, 905	2, 042, 911
Holland	315, 931	231, 737	412, 057	506, 365	471, 259	463, 086	447, 209	454, 019	480, 891	411, 555
Italy	468, 426	455, 228	768, 573	808, 395	906, 925	764, 045	909, 363	987, 868	1, 213, 614	1, 072, 928
Russia	356, 781	465, 989	829, 585	913, 788	794, 763	612, 069	883, 435	895, 195	1, 187, 020	1, 028, 903
Spain	469, 692	388, 971	577, 698	554, 818	592, 567	578, 095	544, 319	648, 605	762, 569	826, 471
Sweden	214, 729	241, 496	385, 864	397, 550	507, 608	532, 342	600, 270	740, 824	1, 148, 617	775, 284
United States	309, 869	....	107, 869	151, 848	108, 271	87, 641	111, 679	92, 306	....	138, 514

IV.

AUSTRALIA.

THE AUSTRALIAN EXHIBIT.

Four colonies represented.

The Australian colonies represented at the Exposition, viz, Queensland, New South Wales, Victoria, and South Australia, made a fine exhibit of ores and metals and of photographs of localities and mining operations. Mining appliances were, unfortunately, absent, but on the other hand descriptive and statistical information were freely distributed.

A collection of ores and products must be supplemented by statistics.

After all, an exhibit of ores and products serves as little more than an illustrated index to the mineral industry of a country. For any comprehensive view of the subject one must necessarily have recourse to printed information, whether statistical or technical.

Extraordinary variety and abundance of Australia's mineral resources.

An attempt will be made in the following pages to present such a sketch of the mining industries of the great southern continent as it is supposed will be welcome to Americans, not altogether neglecting applied science nor omitting to trace the developments and achievements of the purely commercial side of mining. The astonishing variety and abundance of the mineral resources of Australasia, and more particularly of New South Wales, and, as it seems, of the islands of New Zealand, where development has scarcely yet begun, make them an interesting subject for the technologist and an important one to those who "go down to the sea in ships."

The sources of the author's information.

An extensive but somewhat desultory literature of the Australian mineral resources exists. The writer has availed himself, in addition to the catalogues, essays, and pamphlets distributed at Paris, of a variety of works and scattered memoirs, and would gladly have extended his inquiries to many publications not within reach. It is not too much to hope that one result of the approaching International Exhibition in Australia will be a wider dissemination in America of the valuable documents in the publication of which the colonial governments have shown a most intelligent regard for technology and science.

The approaching Melbourne International Exhibition of 1880.

It has been the writer's intention to accredit all information to the proper sources.

The mineral resources of Australia.

AUSTRALIA.

Its mineral resources.

So little attention is, in general, devoted to Australia, the character of the country, and its resources, that a few words of general description may not inappropriately precede an account of its mineral industry.

Area of Australia about the same as the United States, Alaska excluded. Aridity of interior.

Australia has an area of 3,000,000 square miles, or approximately the same as that of the United States, excluding Alaska. The interior of the continent is a desert, and one-third of it is practically unexplored. Leaving out of consideration the comparatively insignificant colony of West Australia, the interest concentrates upon four colonies in the eastern and southeastern portion of the territory. The eastern side of the continent is occupied by Queensland, New South Wales, and Victoria. Queensland is the most northerly and the largest of the colonies; Victoria the southernmost, smallest, and most populous. On the south shore and immediately west of New South Wales and Victoria lies South Australia. The four colonies offer a continuous coast, occupying perhaps three-eighths of the circumference of the continent. The settlements cover a strip of country extending two or three hundred miles inland, and amounting to perhaps one-fifth of the area of Australia. The population of these four colonies exceeds 1,600,000.

The eastern colonies,

and the southern.

Settlements and population.

Physical character of Eastern Australia similar to the Pacific coast of North America.

The physical character of Eastern Australia is remarkably regular and resembles Western America in its most striking features, essentially as it differs from the Pacific coast in a geological aspect.

The coast range,

and divergent spurs.

From one end to the other of the east side runs a chain of cordilleras parallel to the coast. The main ranges are at an average distance of not more than 100 miles inland, and their average elevation is not over 1,500 feet, although peaks in the southern portion rise to 7,000 feet. Subordinate parallel ranges and divergent spurs occupy a tract of country extending some hundreds of miles from the coast, and the main range turns westward for some 400 miles at its southern extremity, still following the shore line. It is almost a matter of course that the line of the great cordillera should experience local deflections from its general direction, and these deviations would not be referred to but for the extraordinary fact that strike of the slates and other older sedimentary strata upheaved along this chain preserves a meridianal course irrespective of the mountain formation. The strike of the slates consequently crosses the westerly branch in which the cordillera terminates at its southern extremity at right angles, and crosses more northerly bends in the chain

Upheaval of the older sedimentary strata.

AUSTRALIA.

Its mineral resources.

at an angle equal to their deviation from the meridian; and so strictly uniform is this line of fracture that bewildered travelers in the mountains refer to the slates to regain their bearings.

Comparison of Australian and the Pacific coast.

It was once supposed that the geology of Australia and the Pacific coast were nearly allied, and analogies there unquestionably are; but these tend rather to prove the prevalence of similar physical and chemical conditions in various geological eras than the coeval development of the mineral resources of the two most important gold-bearing regions of the world. In fact, so far as the formations found in the two localities are concerned, they may be said to be almost antithetical, in some respects much to the advantage of Australia.

Indications of similar physical and chemical conditions at different geological eras.

Rocks specially developed in Western Australia.

In Western Australia Archæan granites are largely developed, while the Silurian is represented only by occasional patches. The Tertiary is well developed in Western Australia and along the southern coast into Victoria. On the eastern coast, with its cordillera, however, it is doubtful whether any Azoic rocks have been found, the crystalline schist, etc., being referred to the lower Silurian. Paleozoic rocks are very highly developed, as are also the Mesozoic, while except at its northern and southern extremities the great mountain belt of Eastern Australia lacks the Tertiary.

Absence of certain rocks in the eastern coast range.

The eastern cordillera.

The eastern cordillera of Australia is then a mountain range which has been upheaved in Paleozoic and Mesozoic formations. The disruption has been accompanied by outbursts of igneous rocks, apparently of many different ages; and this action has been accompanied by more or less metamorphosis or transmutation.

Its upheaval, disruption, etc.

Vast ore deposits on a belt of 250 by 1,700 miles.

These are plainly geological conditions likely to be accompanied by ore deposits, and such there are in wonderful variety, covering a belt coincident with that of the settlements, two or three hundred miles wide and 1,700 miles long.

There is a second belt of mineral deposits in South Australia, where there exists a comparatively small range of mountains, also running north and south, at a distance of some 700 miles west of the more important chain. The predominant ores in the South Australian chain are those of copper, and in their parallelism and difference of mineralization we recognize an analogy to the successive ore-bearing belts of the region of the Pacific. New Zealand may be regarded as a second parallel mineral belt.

Parallel ore belt of South Australia,

and of New Zealand.

Unequaled variety of valuable minerals

The variety of valuable minerals met with in the Australian coast ranges is unequaled in any other part of the world. Gold, copper, tin, and coal are indeed the principal

AUSTRALIA.

mineral products, but several others are of no trifling commercial importance, as bog-head mineral or "kerosene shale," iron, lead, and silver and antimony, while diamonds and a variety of other gems and quicksilver have been sought for with some success.

Its mineral resources.

The importance of the rainfall to mining interests, and more particularly to gold mining, is well known wherever this industry is pursued. In Eastern Australia the rainfall is much as might be anticipated from the general physical features. On the coast the yearly rains amount to, say, from 20 to 50 inches. The quantity diminishes toward the interior, and on the western slope of the cordillera some places escape rain altogether. In California the placer mines are on the wet side of the enormous range of the Sierra Nevada, which serves as a reservoir for a large fall of rain and slowly melting snow. In Australia the comparatively small range of mountains and the distribution of deposits is against the miner, who is often compelled to contend with lack of water.

The rainfall in its influence on mining interests.

Australia and California.

A comprehensive idea of the mineral industry of Australia is less common than it would be but for the political constitution of the country. The four colonies have no political connection, nor is there any co-operation in the matter of surveys, mineral statistics, and the like. Hence data must be sought independently for the mining districts of each colony, although no natural division exists between them. It will be the object of the following remarks to trace briefly the past history and present condition of each of the more important mining industries, independently of political divisions.

The colonial division of the country as affecting the collection of comprehensive mining statistics.

Gold.—It was of course the secondary stream or placer deposits of gold which first attracted attention. It was formerly supposed that these gravel deposits containing water-worn gold were of recent origin. It has been shown, however, that the period of their formation extends back into the Paleozoic eras. Mr. C. S. Wilkinson writes as follows: "North of Gulgong, at Tallawang, the coal measures cover a large area of country; their lowest beds have been found to be payably auriferous. * * * The gold is coarse in size, remarkably scaly, and water-worn. * * * These alluvial deposits are of four periods, Pliocene, Upper Pliocene, Pleistocene, and Recent; and now we can add another—the Carboniferous—the oldest formation as yet discovered containing drifted or water-worn gold." Rev. W. B. Clarke had previously discovered minute quantities of gold in carboniferous conglomerate. As in California, the auriferous

Gold.

The placer deposits the first to attract attention.

C. S. Wilkinson.

The periods of the alluvial deposits.

Rev. W. B. Clarke.

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Its mineral resources.

Gold.

gravels are not infrequently covered with beds of volcanic rock.

Gold is also found in place, and a very large proportion of the metal now yearly extracted is obtained from veins. For a time it was maintained that these veins were remunerative (the Australians use the somewhat ambiguous expression "payable") only in certain formations, and that deep mining must necessarily be unprofitable. It has been conclusively shown, however, that while the majority of paying veins are found in certain formations, rich veins also occur in others, and that there is no tendency of veins otherwise favorably placed to give out in depth.

Gold in veins.

The typical ~~habitus~~ habitat of gold in place in Australia is in quartz veins, and in the southern portion of the gold belt (Victoria) the gold is chiefly derived from veins or "reefs" in the Lower Silurian, without being confined to this formation. In the central portion of the chain of the cordilleras, gold is more generally distributed, and in Queensland "micacious diorite, serpentine, pyritous felstone, and compact quartzite are gangues in many localities, to the total exclusion of quartz." Gold *in situ*, however, is not confined to veins. It is also met with in igneous rocks and sedimentary strata. Mr. Clarke says:* "Much of the gold in New South Wales is derived from iron pyrites in granite, and in *beds* of sedimentary origin. * * * In New Zealand gold sometimes occurs so mixed with silicious particles as to constitute with them a gold sandstone." Elsewhere † he says of Queensland: "Oftentimes, where there is no reef or vein of any kind, the whole mass of the rock is charged with gold." Mr. Wilkinson states,‡ as a remarkable fact, long since pointed out by Mr. Clarke, that the hornblendic granites of New South Wales are auriferous. In all the gold fields recently examined Mr. Wilkinson has noticed that hornblendic granites and intrusive diorite are the original sources from which the gold in the gravel deposits has been derived. Gold, moreover, seems to accompany iron pyrites everywhere in ancient and recent formations. To leave out less extraordinary occurrences, Mr. Clarke speaks of the discovery of a lump of gold in a lump of coal; and Mr. R. B. Smyth mentions § that the pyrites from an old tree trunk was examined, the yield of which was at the rate of over 30 dwt. per ton.

The origin of the gold in Victoria; in Queensland; in New South Wales; in New Zealand.

The origin of the gold in gravel deposits.

Found in coal. R. B. Smyth.

* *Mines and Mineral Statistics of New South Wales, p.* 153.

† *Progress of Gold Discovery in Australasia from* 1860 *to* 1871.

‡ *Annual Report of Department of Mines, N. S. W.*, 1875.

§ *Gold Fields and Mineral Districts of Victoria*, p. 261.

AUSTRALIA.

Its mineral resources. Gold. H. A. Thompson.

The physical structure and the lithological character of the surrounding rocks both affect the yield of quartz veins in Australia. Mr. H. A. Thompson, a well-known mining engineer, has observed* that only partially decomposed granites and diorites carry gold-bearing veins, and that if the decomposition of the adjacent rocks penetrates only to a small depth the quartz veins cease or become barren. Veins, too, crossing planes of bedding or stratification, or at the contact between unconformable beds, are richer than others. In short, the conditions for infiltration must exist. It is a mistake to suppose that highly altered strata are indispensable to paying quartz, many of the best veins being in unaltered, soft Silurian beds. The influence of intrusive hornblende granite and diorite is marked, veins which are very rich so long as they are in these rocks losing their gold contents on passing into adjacent schists. The best veins are laminated in structure, and carry large quantities of sulphurets.

Structure and character of the adjacent rocks as affecting the yield.

Australian gold is, on the whole, finer than Californian. Mr. J. C. Booth, of the United States Mint, states† that the average fineness of California gold, derived from assays of several hundred million dollars' worth, is 0.880. In Victoria, which has been the most productive of the colonies, the value of the gold product is officially estimated at £4 per ounce, which corresponds to a fineness of 0.942, nearly. From the data given in *Mines and Mineral Statistics of New South Wales* for the product of that colony up to the end of 1874, I find the average there 0.876. Indeed, Mr. Clarke and others have long ago drawn attention to the remarkable fact that the fineness of Australian gold diminishes from the south northwards, and Dr. Hector has shown that the same law prevails in New Zealand.

Relative fineness of Australian and Californian gold. J. C. Booth.

In Australia the fineness diminishes from the south northward. Dr. Hector.

Public recognition of the auriferous character of Australia was curiously delayed.‡ Count Strzelecki discovered gold in Australia in 1839, but was restrained from publishing the statement on account of the danger of its producing insubordination in the penal settlements. In 1841 Rev. W. B. Clarke rediscovered it, but the governor of New South Wales induced him to refrain from mentioning it on account of the prejudicial effect it might have on the colony. In 1844 Murchison pronounced it likely that Australia would be found to be a gold-bearing country. Gold nuggets of small size were sometimes found by shepherds, and not only

Delay in public announcement of gold in Australia. Count Strzelecki, 1839. Rev. W. B. Clarke, 1841. R. J. Murchison, 1844.

* *Gold Fields and Mineral Districts of Victoria*, p. 240

† Dana's *Mineralogy*, p. 5.

‡ See *Gold and Silver*, by Mr. J. A. Phillips.

AUSTRALIA.

Its mineral resources. Gold. E. H. Hargreaves. Ballarat.

brought to the settlements, and even exhibited there, but sent to England. Yet it was not until a returned Californian miner, Mr. E. H. Hargreaves, set to work at Ballarat, that the auriferous character of the country was realized.

Attention once aroused, the discoveries of alluvial "diggings" multiplied with great rapidity, and such were soon discovered from one end of the cordillera to the other. Quartz veins were also soon discovered, and, as in California, an increasing proportion of the gold has been extracted from this matrix.

Area of gold diggings.

The area of the gold diggings varies from year to year, surface deposits being exhausted and abandoned. The following are the most recent data accessible as to the extent of ground being worked in:

	Sq. miles.
Victoria, in 1876	1,134
New South Wales, in 1876	1,370
Queensland, in 1873	1,367
Australia, say	4,000

Yield of quartz per ton.

The yield of quartz per ton (2,240 pounds) varies in the different colonies, and indeed in inverse ratio to the fineness, as might be supposed. The following table represents the gold per ton in the parcels respecting which the mining officers succeeded in obtaining information:

	Oz.	Dwt.	Gr.
Victoria, in 1876		10	13.48
New South Wales, in 1876		13	8.20
Queensland, in 1873	1	14	20

The poorest parcel crushed in New South Wales in 1875 yielded only 1 dwt., or, say, $1 per ton, and in 1876 quartz scarcely better was milled. The lowest yield should indicate the cost, but such rock can only have been crushed in ignorance of its contents.

Proportion of gold obtained from placers and from veins.

The proportion of gold obtained respectively from alluvial deposits and from veins is not precisely ascertainable. Of the gold, the history of which was learned by the mining officers of New South Wales in 1876, more than two-thirds was obtained from quartz, but the entire quantity thus traced was only something like one-third of the total product, and it is evident that it must be easier to get reports from mills than from diggings. Ten years since, the proportions estimated in Victoria were just the reverse of the above relation. It seems probable, therefore, that the quantities obtained by mining and by washing are very much the same.

New Zealand.

New Zealand did not exhibit at Paris. For the sake of completeness, however, it may be interesting to add a few

AUSTRALIA.

Its mineral resources. Gold. New Zealand. Dr. A. Soetbeer.

words on the subject of that colony, which are translated from the memoir of Dr. A. Soetbeer: *

"*New Zealand.*—In 1852 about 1,000 ounces of gold were obtained upon the east side of the north island at Cape Coromandel, after which the workings were abandoned. Four years later a beginning was made at the south, in the province of Otago. A great increase in the gold production of New Zealand took place in the summer of 1861, when new and very rich deposits were discovered on the Tuapeka River and in the Thames gold fields. The north island has thus far produced far less gold than the south island, which is much richer in alluvial deposits.† The most important districts stretch along on the western slope of the mountains through Nelson and Westland Provinces toward Otago. Throughout Otago, where they are especially numerous and rich, their distribution is dependent upon the slate rocks. The younger gold-bearing drifts at the bottom of existing valleys are distinguished from deeper and older alluvia upon the declivities. In fact, the rivers of New Zealand have eroded their beds greatly since the formation of the older alluvia, so that the deep leads, which in other districts can often be reached only with great trouble and expense, are here not infrequently exposed upon the declivities of the valleys.

Successive discoveries of gold districts.

The gold-bearing drifts of different periods.

"Hydraulic washing on the California plan has been introduced in Otago.

"The comparatively small extension of the gold districts among the younger volcanic rocks as contrasted with the great development of alluvia from the slates justifies the prediction that the fate of New Zealand will be that of California."

Product of gold mining in Australia and New Zealand.

The following table exhibits the results of gold mining in Australia and New Zealand. The gold product of South Australia and Tasmania has been fitful and insignificant. The data for Victoria are official reports of the mining registrars; for New South Wales, in part from a similar source and in part from analyses of the mint and custom-house reports, made by the mining authorities of that colony. The data for Queensland and New Zealand are taken from Dr. Soetbeer's memoir. Dr. S. arrives at all his figures for

* *Edelmetall-Produktion und Werthverhältniss zwischen Gold und Silber.* (Production of precious metals and relative value of gold and silver.) This memoir, the most extensive that has appeared on the subject, has just been published as an extra number to "Petermann's Mitheilungen." It seems exhaustively compiled and admirably digested.

† E. Suess, *Zukunft des Goldes*, Wien, 1877.

AUSTRALIA.

Its mineral resources. Gold.

Australia by discussing the importation and exportation of gold, and allowing a certain amount for circulation, etc., in the colonies. It is satisfactory to find that his final result is only two million pounds, or about three-fourths of one per cent. less than that here given, although less than one-fifth of the total has been reached from the same data.

Table of gold product of Australasia.

Value of the Australasian gold product.

Years.	Victoria.	New South Wales.	Queensland.	New Zealand.	Australasia.
Prior to 1870 ...	£152, 624, 816	£24, 275, 660	£1, 262, 622	£18, 162, 232	£196, 325, 330
In 1870	4, 891, 192	931, 016	483, 165	2, 062, 600	8, 367, 973
1871	5, 421, 908	1, 250, 485	584, 481	2, 608, 740	9, 865, 614
1872	5, 130, 084	1, 643, 582	438, 613	1, 502, 043	8, 714, 322
1873	4, 964, 820	1, 395, 175	623, 199	1, 728, 670	8, 711, 864
1874	4, 623, 888	1, 040, 329	1, 313, 204	1, 364, 720	8, 342, 141
1875	4, 383, 148	877, 694	1, 434, 219	1, 382, 282	8, 077, 343
1876	3, 855, 040	613, 190	1, 246, 296	1, 228, 864	6, 943, 390
Total	185, 894, 896	32, 027, 131	7, 385, 799	30, 040, 151	255, 347, 977
Maximum yield ..	11, 943, 964 (In 1856.)	2, 660, 946 (In 1852.)	1, 434, 219 (In 1875.)	2, 784, 124 (In 1866.)	12, 663, 034 (In 1856.)

Or, in money of the United States (taking the pound at $4.86), as follows:

In 1876	$18, 735, 494	$2, 980, 103	$6, 056, 999	$5, 972, 279	$33, 744, 875
Total	903, 449, 195	155, 651, 857	35, 894, 983	145, 995, 134	1, 240, 991, 168
Maximum yield ..	58, 047, 665 (In 1856.)	12, 992, 198 (In 1852.)	6, 970, 304 (In 1875.)	13, 530, 843 (In 1866.)	61, 542, 345 (In 1856.)

Dr. Soetbeer's estimate.

The mind fails to grasp these sums, but some idea at least may be obtained by comparison. I therefore add Dr. Soetbeer's results for the gold-producing countries of the world. from the discovery of gold in Australia to the end of 1875. I have added the same statistician's estimate of the silver product of the world for the same period for comparison. The silver production of Australia will be mentioned presently. Dr. Soetbeer is responsible only for the weights. These I have converted into terms of the habitual dollar, at the rate of 1 kilo gold to $664,632, and 1 kilo silver to $41,568.

Table of world's product of gold and silver, 1851–1875.

The world's product of gold and silver, 1851 *to* 1875, *inclusive, according to Soetbeer.*

Countries.	Gold.		Silver.	
	Kilograms.	Dollars.	Kilograms.	Dollars.
Australia	1, 812, 000	1, 204, 310, 000	.. ..	....
United States	1, 840, 500	1, 223, 260, 000	5, 271, 500	219, 124, 000
Mexico and South America.	231, 935	154, 150, 000	18, 570, 500	771, 933, 000
Russia	694, 080	461, 310, 000	397, 790	16, 535, 200
Other countries	177, 850	118, 205, 000	6, 763, 745	281, 153, 000
Total	4, 756, 365	3, 161, 235, 000	31, 003, 535	1, 288, 745, 200

AUSTRALIA.

Its mineral resources. Gold.

Absence of exhibit of gold-mining appliances.

Of the present methods of treating gold-bearing gravels and quartz in Australia it would be interesting to speak, were the necessary information furnished by the Exposition, but Australia exhibited no mining appliances; a fact which is to be regretted, but of which we cannot complain, as American mining apparatus was equally conspicuous by its absence.

Infrequency of hydraulic mining in Australia.

There are few places in Australia where hydraulic mining is practicable, for lack of sufficient water supply. Where alluvial gold is mixed with any adherent material, it has to be "puddled" or stirred up mechanically with water, so that a separation of metal from dirt may be possible; a method avoided in this country almost entirely. Cradles, pans, etc., seem also in vogue in Australian diggings.

Stamp mills.

Statistics of the number and performance of stamp mills.

Loss.

G. T. Deetken.

For crushing quartz the stamp mill is there as here almost the only machine employed. Data are not accessible as to their construction and duty, but the inference from what we know is not favorable. In 1876 there were 1,326 stamp-heads at work in New South Wales, according to the report of the Minister of Mines. But if the quartz ran $13.50, and if half the gold was produced from quartz, this large number of stamps must have crushed only in the region of 370 tons per diem. The loss is estimated at 21.8 per cent. Mr. G. T. Deetken calculated the loss at Grass Valley, Cal., at 27 per cent. (Mining Commissioner's Report for 1873, p. 333.)

Treatment of pyrites.

Plattner's chlorination process.

A new process desirable to save the copper and silver as well as the gold.

W. A. Dixon.

In respect to the treatment of pyrites, the Australian colonies are making vigorous efforts to develop some method more economical or better suited to the ordinary conditions of gold-mining localities than has hitherto been brought to public attention. The Plattner chlorination process has done good service in California, but only pyrites carrying $20 or so per ton will pay for treatment. In England vast quantities of pyrites are treated at small cost, but in connection with the sulphuric acid manufacture and iron smelting; industries ordinarily absent from gold-mining localities. A process for the treatment of this material should be self-contained, or nearly so, and admit of the utilization of at least the copper and silver as well as the gold. The subject is one well worthy of the attention of California engineers, who will find, among other Australian publications, a paper by Mr. W. A. Dixon in the eleventh volume of the *Journal of the R. S. of New South Wales* of interest.

Silver associated with the gold.

Silver.—But little attention has been paid in Australia to silver ores. It may, however, be worth while to point out that native gold always contains silver, and that conse-

AUSTRALIA.

Its mineral resources.

Silver.

quently a very considerable quantity of silver has accompanied the Australian gold product into commercial channels.

Value of the silver associated with the gold.

The value of this silver is relatively so small, that it cannot be taken into consideration in the official estimates of the value of the gold product. In Victoria the value of the gold per ounce is estimated at four pounds, corresponding to a fineness of nearly 0.942, or about 22½ carats. The remaining 0.058 silver would have a value amounting to less than one-half of one per cent. of the total value of the bullion, and it is pretty certain that the official estimate does not possess this degree of accuracy.

Amount of silver contents of the gold bullion.

In spite of the inaccuracy of the estimate of the mean value of the gold bullion, the data may be used to estimate the amount of silver obtained with the gold. The records show that the average fineness of Australian gold is not far from 22 carats, or 0.916⅔. The weight of the silver contents of the gold bullion has, then, been one-eleventh of that of the gold. If one ounce of silver is taken, according to American law, at $1.2929, this calculation leads to an amount of silver worth a little over seven million dollars on my estimate of the gold product up to the end of 1876.

Silver ores.

Ores the valuable contents of which is distinctively silver are found in patches through the gold districts of Australia, not, as in Western America, in separate belts of country.

Product in Victoria to 1876.

In New South Wales.

The amount of silver produced from silver ores in Victoria to the end of 1876 is officially estimated at a value of £21,206. New South Wales has produced, up to the same date, £105,466 worth of this metal. Queensland appears to claim no silver product. The value of the silver from silver ores has there amounted only to some $600,000.

Tin.

Alluvial deposits and lodes.

D. Forbes, 1859.

Stanniferous granite.

Tin.—The uniformity in the character of tin deposits all over the world has long been a subject of remark, and Australia has no exception to offer. Here, too, it occurs in alluvial deposits of various ages, and in place in lodes and reticulated veins, less properly described as "strings," in granite and greisen rocks. Mr. D. Forbes, as far back as 1859, received specimens of stanniferous granite from New South Wales, and found them "perfectly identical with the stanniferous granites of Cornwall, Portugal, Bolivia, Peru, and Malacca," and Banca and Billiton might have been added to the list.

Tin ore found associated with gold.

Crystals of cassiterite in quartz.

The tin ore is frequently found associated with gold, which indeed it greatly resembles in its lithological behavior. It is nearly always associated with quartz, many crystals of the latter mineral showing crystals of cassiterite imbedded in and implanted upon them, whence the conclusion seems inevitable that their deposition has been simultaneous. Arsenical and copper pyrites are also associated with the tin-stone, and diamonds and sapphires occur in the same leads. Their high specific gravity and perfect resistance to atmospheric action account in part for the occurrence of gold and tin-stone together in alluvial deposits.

AUSTRALIA. *Its mineral resources.* Tin.

The stream deposits are not confined to the beds or banks of present water-courses. They often extend high up the sides of the valleys of the present streams (indicating erosion), and are also found in "deep leads" or the beds of ancient streams. The only source of the tin seems to be the granites. On high ground, cassiterite is sometimes found over granite in unworn crystals, and existing there as a residuary deposit. The granites are Paleozoic, and, according to Mr. Clarke, Devonian. The veins do not exhibit a uniform strike as in Cornwall.

Stream deposits. Deep leads. Granites the source of tin.

The tin fields of Australia center on the eastern cordillera, about half-way up the coast, and near the boundary between New South Wales and Queensland, though there is tin ore in the southern portion of New South Wales and in Victoria, and very valuable discoveries have been made in Tasmania.* The area of the New South Wales fields is estimated at 6,250 square miles, and that of the Queensland tin-bearing district at 100 square miles.

Localities of the tin fields. Areas.

Rev. W. B. Clarke, whose active share in the investigation and development of the mineral resources of Australia has so often been referred to, was the first to draw attention to the probable occurrence of extensive deposits of tin ore in Australia. His prediction was made in a report to the colonial secretary of New South Wales, dated May 7, 1853, the subject of which was the district of New England, the same which became so famous for its tin deposits in 1872. No practical notice was taken of Mr. Clarke's observation.

Rev. W. B. Clarke. His prediction in 1853 of the discovery of tin ore deposits.

The existence of tin-stone was recognized in Victoria during the same spring. The occurrence of tin in the more southern colony is comparatively trifling, but the discovery was not entirely overlooked as in New South Wales. As has been pointed out in the report on the mineral industry of Great Britain, relatively considerable quantities of tin-stone and tin were obtained in Australia long before 1872. This appears to have come exclusively from Victoria, which still produces a few scores of tons a year, a quantity quite insignificant in comparison with the recent yield of New

Tin-stone in Victoria.

* See paper by Mr. Wintle, *Trans. R. S. of New South Wales*, vol. 9, p. 87. The deposits seem to present great peculiarities, the ore occurring in sharp detritus and often in lumps weighing hundreds of pounds.

AUSTRALIA.

Its mineral resources. Tin.

Product of Victoria.

South Wales and Queensland. According to the *Victorian Year Book* for 1876–'77, the total value of the tin raised since its first discovery in that colony was £336,391, representing, perhaps, 3,000 tons of metal. The product of 1875 and 1876 cannot have been far from 60 tons per year.

Tin in New South Wales.

The fact of the existence of tin-stone in the northern part of New South Wales fell so entirely into oblivion that in a government volume entitled *Industrial Progress of New South Wales in* 1871, an essay on the mineral resources of the colony contains no mention of this metal. Since 1872 great quantities of tin have been extracted, mainly from stream deposits, and the business of tin smelting has been rapidly mastered. The returns of the tin raised and smelted are confessedly imperfect.

In Queensland.

As the great tin fields lie close upon the borders of New South Wales and Queensland, the discovery of tin-stone in the latter colony was simultaneous with that in the former. The data accessible to me for the production in Queensland are exceedingly unsatisfactory, for in 1874 I have the product for the first quarter only, for 1875 nothing, and for 1876 only a statement of the value. In the following table I have calculated the contents of the tin-stone raised at 70 per cent. metal, and estimated the missing figures as well as I could. These unauthoritative sums are printed in bold-faced figures:

Table of production of tin in Australia.

Approximate production of tin in Australia.

Years.	NEW SOUTH WALES.		QUEENSLAND.		Total probable equivalent in tin.
	Tin and tin ore produced.	Probable equivalent in tin.	Tin ore produced.	Probable equivalent in tin.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1872	Ore .. 848 Tin ... 47	**598**	1,400	**980**	**1,578**
1873	Ore ... 3,635 Tin ... 904	**3,449**	5,274	**3,692**	**7,141**
1874	Ore ... 2,118 Tin ... 4,101	**5,584**	**5,440**	**3,808**	**9,392**
1875	Ore .. 2,022 Tin .. 6,058	**7,473**	....	**3,500**	**10,973**
1876	Ore ... 1,509 Tin .. 5,449	**6,505**	....	**2,800**	**9,305**
Total	....	**23,609**	....	**14,780**	**38,389**

English tin product.

Or, adding **3,000** tons for Victoria, the total becomes, say, **41,000** tons. The English tin product for 1876 was

9,500 tons; Banca and Billiton produced together about 6,600 tons.

Its mineral resources. Tin.

Mr. Wilkinson attributes the falling off in the tin product to the exhaustion of the more accessible alluvial deposits.

Washing in sluices or jigs.

The washing of the tin-stone is effected either in sluices or jigs. As in the treatment of placer gold, the lack of an ample water supply is severely felt. Wolfram seems not to occur with the tin-stone to any considerable extent. The smelting is effected, as in England, in reverberatory furnaces.

Smelting.

Copper.

Copper.—South Australia contains some of the finest copper mines in the world. The following somewhat meager account is extracted from a *Statistical Sketch of South Australia*, by Mr. J. Boothby:

South Australia. J. Boothby.

"The principal mines are the Burra, the Wallaroo, and the Moonta.* From the first of these 215,000 tons of ore were raised during 31 years from the commencement of operations, producing four millions sterling. The total amount expended by the company was £1,982,000, of which £1,568,000 represented wages, the gross profits being £882,000. Since the opening of the Wallaroo mines, the total quantity of ore raised therefrom has been 290,000 tons, and the average of the past five years has been 26,000 tons. The Moonta mines were discovered in 1861, since which year 250,000 tons of ore have been raised, realizing £2,760,000. A profit of £928,000 has been divided amongst the shareholders of this magnificent property.

Product of the principal mines. Burra mines.

Expenses and profits.

Wallaroo mines.

Moonta mines.

"In 1844, shortly after the discovery of copper in South Australia, the total value of the minerals exported was £6,436; in 1851 it reached to £310,916; in 1861 it amounted to £454,172; in 1871 to £648,569; in 1875 to £762,386.

Minerals exported, 1844–1875.

"The following table exhibits the steady productiveness of South Australian mines, distinguishes the quantity of fine copper shipped from the quantity of ore exported in its crude state, and gives the estimated value of each:

Product of South Australian mines, 1866–1875.

Years.	Fine copper.		Copper ore.		Total value.
	Cwt.		*Tons.*		
1866	129,272	£584,509	16,824	£225,683	£824,501
1867	156,863	627,384	11,430	113,409	753,413
1868	104,227	400,691	20,725	207,519	624,022
1869	92,788	371,566	26,835	250,259	627,152
1870	109,421	394,919	20,886	173,861	574,090
1871	127,911	518,080	20,127	119,903	648,569
1872	149,050	680,714	26,964	122,020	806,364
1873	141,744	635,131	27,382	133,371	770,590
1874	132,587	557,306	22,854	136,530	700,323
1875	136,835	578,065	26,436	175,101	762,386

* Burra is 60 miles from Adelaide, on the eastern slope of the South Australian range. Wallaroo and Moonta are close together, 75 miles from the capital, near the base of Yorke Peninsula.

AUSTRALIA.

Its mineral resources. Copper.

"The smelting works in connection with these mines are of a very extensive and costly character, employing a large amount of skilled labor."

Distribution of the copper ore.

Copper is also found in large quantities along the eastern cordillera, distributed over a somewhat wider belt of country than the ores of the other metals. The copper in the eastern colonies, however, labors under some disadvantages in the unfavorable position of the mines for transportation, the large capital necessary to establish smelting works, etc. The returns of copper ores raised and smelted, as well as those of tin, are very imperfect. Up to 1874 the maximum quantity of metallic copper produced in New South Wales was 665 tons; but for the years 1874, 1875, and 1876, respectively, the ingots exported weighed 3,628, 6,245, and 3,106 tons. A small quantity of ore and regulus continues to be exported. The total value of the copper industry in New South Wales before 1874 is estimated officially at about £500,000, and for the years 1874, '75, and '76 together at a little over a million.

Copper production of New South Wales.

Queensland.

Queensland produces some copper ore, and copper mining is there regarded as one of the industries of the future. The value of the copper and copper ore exported in 1872 was £234,540; in 1873, £189,479; and in 1876, £172,380. Copper has figured among the exports of Queensland ever since 1862.

Victoria.

Victoria produces only a trifling amount of copper, the amount raised up to the end of 1876 being valued at only £8,331.

Copper product of Australia.

These desultory data convey very little idea as to how much copper Australia has produced. A rough approximation may be made as follows:

Value of copper and copper ore raised in South Australia to the close of 1875	£14,404,568
From the product of former years we may estimate for 1876	**750,000**
Value of copper product of Victoria to end of 1876	8,331
Value of product of New South Wales to end of 1876	1,566,232
Value of Queensland product to end of 1873	955,592
Value of Queensland product for 1876	172,380
Value of Queensland product for 1877 and 1875, estimated same as 1876	**344,760**
Total value of Australian product	18,201,863

Value of Australian copper product.

Price of copper.

The average price of copper (tough cake) in England for the years 1870 to 1876 (7 years) was within twopence of £84 10*s*. But a large proportion of the copper raised in Australia was exported as ore and valued accordingly. The

AUSTRALIA.

Its mineral resources. **Copper.**

price of copper ore containing 20 per cent. copper, in Swansea, is about 80 per cent. of the market value of the copper therein contained. For lack of data we may suppose one-half of the copper in ingots and one-half as ore; or that the value per ton of the copper raised as it was exported was 90 per cent. of the market price of tough-cake copper, or, say, £76 per ton. This assumption leads to a total copper product for Australia, to the end of 1876, of about 240,000 tons. In 1876 Great Britain produced about 4,700 tons.

Value of copper product.

Coal. Cordilleras of Eastern Australia.

Coal.—Large coal fields exist along the cordillera of Eastern Australia. A somewhat animated discussion has been carried on regarding their geological position, viz, as to whether they are Paleozoic or Mesozoic, a question thought to bear forcibly upon the probabilities of their extent and quality. The discussion originates in the fact that the greater part of the fossils found in the coal beds are distinct from any recognized in Europe as characteristic of the carboniferous formation. Especially is this the case with plants of the genus *Glossopteris*, which are characteristic of the most valuable portion of the Australian coals. The evidence of the fossil fauna, however, seems to have decided the question in favor of the Paleozoic character of the main deposits. There are also large fields of Mesozoic coal of less but by no means small value.

Fossils peculiar to the anthracite coal beds.

Paleozoic character of the principal beds indicated by the fossil fauna.

Position and extent of the coal fields, New South Wales.

The position of the coal fields is mainly between the cordillera and the coast, and while the gold deposits center in Victoria, the coal fields are most abundantly developed in New South Wales. These coal fields extend northward into Queensland, which unquestionably possesses ~~numerous~~ enormous quantities of coal, hitherto almost untouched. Victoria also possesses coal, chiefly Mesozoic. The carboniferous formation in Victoria is very much broken up, and Mr. Selwyn has referred to the drifted origin of the material forming the Paleozoic coal of Victoria as precluding the probability of the existence of workable coal seams in the Victoria coal measures. In contrast to this condition of things, Mr. Wilkinson remarks upon the frequent occurrence in the coal seams of New South Wales of tree trunks, upright, and evidently undisturbed.

Victoria.

A. R. C. Selwyn.

Tree trunks in situ.

South Australia.

Reports of the discovery of coal beds in South Australia have been circulated from time to time, but have hitherto, so far as I know, proved groundless. Coal has long been known to exist on the west coast of Western Australia, but it is not worked to any considerable extent.

Western Australia.

Principal localities of coal.

The developed coal fields are, then, to all intents and purposes, confined to New South Wales, though Queensland

AUSTRALIA. *Its mineral resources.* claims 24,000 square miles of developable coal lands, and Victoria has mined some $60,000 worth of mineral fuel, chiefly at Cape Paterson, up to the end of 1876.

Coal. The following extract from the official catalogue of the exhibit of New South Wales contains valuable information:

New South Wales, Area of carboniferous strata. "The approximate area of the carboniferous strata is estimated at 23,950 square miles. The principal coal beds exist along the coast to the north and south of Sidney. The mines just opened are situated in the immediate vicinity of Newcastle, and it is from there that the colony obtains its largest supply. Lie of the coal. The coal lies near the surface, and the greatest depth to which shafts have yet been sunk is less than 500 feet. In many districts the coal crops out on the face of the hills, and can be cheaply got by driving tunnels. Cost of mining. The cost of mining is from 3*s.* to 5*s.* 6*d.* per ton.

Quality. Report from Royal Arsenal, Woolwich. "Experiments with the New South Wales coal at the Royal Arsenal, Woolwich, in 1858 and 1859, showed that for steam purposes it was only 7 per cent. inferior to the best Welsh coal, and that, as regards the manufacture of gas, it produces upwards of 9,000 feet per ton, with an illuminating power 24 per cent. greater than the English variety known as Whitworth. Director of Indian Railway Companies. The government director of the Indian railway companies, in his report to the Secretary of State for India (1868–'69), refers to the quality of Australian coal. He says: 'It has been tried on some of the lines of Western India, and has been well reported on. The experience of the locomotive superintendent of the Scinde Company Scinde Railway Company. Comparison with Welsh coal. is that it is equal to Welsh coal in all respects; its evaporative power is nearly equal to Welsh coal, and the consumption per mile is less. The price hitherto has been under that of English-Welsh coal.'

John Mackenzie. "The government examiner of coal fields (Mr. John Mackenzie, F. G. S.) estimates that one seam of coal, after allowing one-third for loss and waste in getting, will yield Estimated yield of coal seams. 84,208,298,667 tons. It has been ascertained by the Rev. Rev. W. B. Clarke. W. B. Clarke and the examiner of coal fields that there are in the upper coal measures at least 16 seams of coal, each more than 3 feet thick. One seam, whose outcrop is near W. Keene. Stroud, described by the late Mr. W. Keene, is more than 30 feet thick, as tested by several trial pits sunk on the dip side; and another, whose outcrop is near Wallerawang, A. Liversidge. recently examined by Archibald Liversidge, esq., professor of geology in the University of Sydney, is 17 feet 6 inches thick. The principal seam from which coal is now being obtained is from 8 to 10 feet thick, the coal being free-burning and bituminous—suitable for household, steam, smelting, gas, and blacksmith's purposes.

AUSTRALIA.

Its mineral resources. Coal. R. W. Moody.

"Mr. R. W. Moody, mining engineer, gives the following description of coal land on the southeastern coast: 'The 5 seams of coal contained in these 600 acres will yield 31,250,000 tons of coal, which will supply a vend of 1,000 per day for over 100 years; and this is independent of the exceedingly rich bed of kerosene-oil shale, which is sufficient to yield 2,000 gallons of refined oil per week for over 72 years. The position of all the seams is so favorably situated, that the coal from each can be got by tunneling into the mountain range, and conveyed to the proposed railway terminus below by self-acting inclined planes.' Writing of the upper coal measures in the western district, the government geologist (C. S. Wilkinson, esq., F. G. S.) says: 'They are 480 feet thick, resting conformably on the marine beds of the lower coal measures, and overlaid by more than 500 feet of Hawksbury sandstone. Eleven seams of coal have been counted in them: the lowest, which is 10 feet thick, lies about 25 feet above the marine beds, and is the same seam worked by Bowenfels, Eskbank, Lithgow Valley, and Vale of Clwydd Collieries. This seam of coal crops out on the surface on the railway line near Bowenfels. It dips at a low angle of 3 to 5 degrees to the northeast, and is therefore easily worked; and as it passes under the vast extent of mountain ranges to the north and east, it will be inexhaustible for generations to come.'"

Coal of the southeastern coast.

Kerosene-oil shale.

C. S. Wilkinson on the upper coal measures.

The following table of the output, home consumption, and mean yearly price of coal in New South Wales is taken from the Annual Report of the Department of Mines for 1876:

Statistics of coal output, consumption, and price.

Coal in New South Wales.

[Output, consumption, and price.]

Years.	Output.	Consumption.	Price.
	Tons.	*Tons.*	*s. d.*
1829–1869	8, 110, 076	....	....
1870	868, 564	290, 175	7 3. 54
1871	898, 784	333, 355	7 0. 47
1872	1, 012, 426	343, 316	7 9. 92
1873	1, 192, 862	419, 783	11 1. 94
1874	1, 304, 567	431, 587	12 1. 37
1875	1, 329, 729	402, 722	12 3. 89
1876	1, 319, 918	451, 101	12 2. 06
Total	16, 036, 926	....	....

New Zealand, which seems to form the other edge of a great submerged basin whose western boundary is the East Australian cordillera, possesses immense coal fields,

New Zealand

AUSTRALIA.

Its mineral resources.

the product being, it is stated, even superior to that of New South Wales. Tasmania also is rich in coal, of which a few thousand tons are yearly raised.

Kerosene shale.

Nearly allied to coal is the "kerosene shale," "kerosene-oil cannel coal," or Australian boghead mineral. Boghead coal is of limited local occurrence in Scotland. It consists chiefly of the mineral torbanite, which is nearly allied to cannel coal, and contains, according to Dana, carbon 82.19, hydrogen 11.64, oxygen 6.17. In New South Wales boghead coal and similar bituminous shales are found extensively in association with the coal beds—the boghead sometimes passing over into ordinary coal, sometimes interstratified with it. The official estimate of the area of workable seams of this substance in New South Wales is 660 square miles. The value of boghead and similar coals, both for the manufacture of an oil resembling petroleum and for gas manufacture, is well known. The Hartley shale yields from 150 to 160 gallons of oil per ton, or 18,000 cubic feet of gas, with an illuminating power equal to 40 candles. This is more than is commonly claimed for the Scotch boghead.

New South Wales.

Area of workable seams.

Yield of Hartley shale.

Analysis.

An analysis * of best Hartley shale gave:

Volatile	86.6
Fixed carbon	6.8
Ash	6.6
	100.0

Export.

Competition with American petroleum.

The mineral is largely exported for gas-making. The oil competes in Australia with American petroleum, but apparently with no great margin in its favor, as one of the principal sources of supply seems to be worked or not according to the market rate for petroleum. The oil is said to be equal to American petroleum in illuminating power, and superior in safety; and Mr. Reid reports that the oil of the New South Wales Shale and Oil Company "has secured the market to the extent of 300,000 gallons, with increasing demand." From the returns in the mining reports of shale raised by them it is plain that this is their aggregate, not the yearly sale of this company.

Sales.

The amount of shale obtained in Victoria appears to be insignificant, and in Queensland no attention has as yet been paid to it.

The following table exhibits the progress of the oil-shale industry in New South Wales:

* *Mineral Map and General Statistics of New South Wales.*

Kerosene oil shale.

AUSTRALIA.

Its mineral resources.
Kerosene-oil shale.

Years.	Quantity in tons.	Price per ton. £	s.	d.
1865	570	4	2	5.47
1866	2,770	2	18	10.48
1867	4,079	3	14	9.21
1868	16,952	2	17	7.11
1869	7,500	2	10	0
1870	8,580	3	4	3.18
1871	14,700	2	6	3.91
1872	11,040	2	11	11.91
1873	17,850	2	16	6.55
1874	12,100	2	5	1.48
1875	6,197	2	10	2.22
1876	15,998	3	0	0
Total	118,336			
Average		2	14	10.95

Production and price, 1865–1876.

Lead.—Ores of lead, largely argentiferous, are known to exist in Australia, and a few thousand dollars' worth of the metal have been produced in South Australia and Victoria. In New South Wales the plumbiferous area is estimated at 500 square miles, but there are no returns of product and no mines working. Lead.

As a mineralogical curiosity it may be mentioned that Mr. Smyth states * the occurrence of native lead sometimes studded with gold in deep gold leads at Talbot and Avoca, where they have frequently been seen *in situ* by competent witnesses. The specimens have not been analyzed.

Antimony.—Antimony is met with in various localities in New South Wales. From 1871 to 1874 72 tons of the ore, valued at £897, were treated. In 1875 the production was 142 tons regulus, valued at £5,000. In 1876 40 tons of ore, valued at £140, were raised. Antimony.

In Victoria there are five antimony smelting works, and £120,000 of antimony had been raised up to the end of 1876.

Gems, though of frequent occurrence in Australia, have thus far paid but poorly, for while many stones of high quality are found in some gold and tin leads, the size is almost always small. Gems.

Mercury.—Rev. Mr. Clarke writes as follows, in the *Mines and Mineral Statistics of New South Wales*, 1875: Mercury. Rev. W. B. Clarke.

"Some years since I reported on the occurrence of mercury in this colony, but my expectation of the discovery of a lode of cinnabar has been disappointed. The cinnabar occurs on the Cudgegong in drift lumps and pebbles, and is probably the result of springs, as in California [?]. In New Zealand, and in the neighborhood of the Clarke River, North Queensland, the same ore occurs in a similar way. Cinnabar.

* *Gold Fields of Victoria*, p. 420.

AUSTRALIA.

Its mineral resources.

Mercury.

About 1841 I received the first sample of quicksilver from the neighborhood of the locality on Carwell Creek, on the Cudgegong, where the cinnabar is found."

Cinnabar and mercury exhibits.

In the Annual Report of the Department of Mines for 1875 it is mentioned that "a cinnabar mine has lately recommenced work" in the district mentioned by Mr. Clarke, which lies near the center of the gold fields; but the report for 1876 passes it over in silence. Samples of ore and quicksilver at Paris made a handsome show, but were accompanied by no information as to the prospects or yield.

Iron.

The *Iron* producing capacities of Australia are unquestionably great, but they are little developed, and do not belong to this report.

V.

RUSSIA.

THE MINING INDUSTRY OF RUSSIA.*

Mineral wealth.

Variety and wide distribution.

The mineral wealth of Russia is very large, and is based upon a great variety of substances, widely distributed throughout the empire. Its principal metals are gold, platinum, silver, copper, lead, and iron; tin, zinc, nickel, and cobalt are developed to some extent, but are of minor importance. Coal is said to exist in immense quantity in Southern Russia, and its production, already considerable, shows a steady increase during late years. Salt, sulphur, graphite, precious stones, etc., contribute also to the value of the mineral product.

Metals, Coal, Salt, sulphur, graphite, gems.

The principal sources of the more valuable metals are in the mountain ranges of the Ural and Altai. Copper is not only found in great abundance in the regions just mentioned, but also in the Caucasus, in Finland, and in the Kirghese district. Iron also occurs abundantly, not only in the Ural and in some portions of the Altai, but in some of the central and southern departments of the empire, in Poland, Finland, and in the north. The zinc mines of Poland are counted among the richest of Europe. A single mine in the government of Viborg, Finland, furnishes the entire tin product of Russia, but this is very irregular, and of late years very small.

Precious metals of the Ural and Altai ranges. Copper. Iron. Zinc. Tin.

The mines of Russia did not assume much importance in the industries of that country until about the beginning of the eighteenth century. Thence until the reign of Elizabeth their development progressed rapidly; but in the latter half of the past century a period of stagnation ensued, which lasted, for reasons partly political and partly economical, for many years. Of late, however, the mining industry has shown in most departments a very considerable ad-

Former importance, followed by stagnation. Revival of interest.

* The substance of this paper is drawn chiefly from official or semi-official sources, published by the administration of Department of Mines of the Russian Government. Most of the figures are taken from a pamphlet prepared for the occasion of the Paris Exposition, entitled *Tableaux Statistiques de l'Industrie des Mines en Russie en* 1868–1876, *par C. Skalkovsky, ingénieur des mines.* M. Skalkovsky is the secretary of the *Comité Scientifique des Mines*, and the statistics of the department are prepared and published under his supervision.

RUSSIA.

Mineral wealth.

vance. Its progress during the last fifty years is shown by the following table:

Production of metals and minerals, 1830–1875.

Production of sundry metals and minerals in the Russian Empire during years named below.

(Table from page 14 of "Statistics," given in poods.)

Years.	Gold.	Silver.	Platinum.	Copper.
	Poods.	*Poods.*	*Poods.*	*Poods.*
1830	383	1,282	107	238,995
1835	393	1,212	105	240,204
1840	458	1,280	108	280,918
1845	1,307	1,192	1	260,048
1850	1,454	1,068	9	393,618
1855	1,649	1,043	....	378,618
1860	1,491	1,070	61	315,693
1865	1,576	1,084	139	253,037
1870	2,155	868	119	306,387
1875	1,955	601	94	222,291

Years.	Cast iron.	Coal.	Salt.	Naphtha.
	Poods.	*Poods.*	*Poods.*	*Poods.*
1830	11,169,328	} 600,000	{ 20,920,393	261,000
1835	10,500,146		{ 22,500,000	348,956
1840	11,331,510	875,000	27,195,512	337,009
1845	11,432,645	....	55,476,527	327,166
1850	13,892,325	3,160,000	24,829,009	255,000
1855	15,310,616	2,500,000	32,224,453	....
1860	18,174,125	8,000,000	26,109,602	....
1865	16,046,191	12,679,311	29,058,933	554,291
1870	19,503,407	22,163,107	29,013,458	1,704,455
1875	23,255,068	79,444,328	37,591,399	8,174,340

The pood, consisting of 40 Russian lbs., is equal to 16.3808 kilos; 1 pood is equal to 36.1131 lbs. avoirdupois; 1 pood is equal to 526.58 troy ounces; 61.047 poods equal 1,000 kilos = 1 French tonne = 2,204 lbs.; 55.3815 poods equal 2,000 lbs. avoirdupois.

Gold. Production from 1753–1876.

Gold.—The production of gold in Russia, since its commencement in 1753, amounted at the end of 1876 to 67,134 poods, the approximate value of which may be placed at $730,000,000.

The production during recent years is shown in the following table:

Production, 1867–1877.

Production of gold from auriferous deposits during ten years.

Years.	Number of exploitations.	Quantity of sand and mineral washed.	Quantity of gold extracted.	Approximate value of product.
		Poods.	*Poods.*	
1867	878	968,423,325	1,650	$17,958,600
1868	993	1,177,288,244	1,711	18,622,524
1869	1,129	1,054,570,392	2,007	21,844,188
1870	1,208	983,475,095	2,157	23,476,788
1871	978	1,081,518,424	2,400	26,121,600
1872	1,055	1,044,027,585	2,331	25,370,604
1873	1,018	954,648,764	2,025	22,040,100
1874	1,035	937,578,045	2,027	22,061,868
1875	1,092	1,007,293,492	1,996	21,724,464
1876	1,130	1,022,543,362	2,054	22,355,736
1877	....	....	2,430	26,448,120

RUSSIA.

Mineral wealth. Gold.

Of this product Siberia furnishes from two-thirds to three-fourths, the remainder coming mainly from the departments of Perm and Orenburg, in European Russia, with small contributions from the Kirghese district and Finland. The product of 1876 is credited as follows to the several governments and territories:

Production of gold by governments.

Government.	Location.	Number of exploitations.	Quantity of gold.
			Poods.
Iakoutsk	Siberia	35	628
Iénisseisk and Irkoutsk	......do	336	386
Transbaïkal	......do	64	234
Amoor	......do	10	172
Tomsk	..... do	126	107
Littoral	.. do	3	12
Perm	European Russia	197	177
Orenburg	......do	263	110
Sémipalatinsk	Kirghese district	24	12
Akmolinsk	..... do	6	1
Uleaborg	Finland	9	½

Imperial concessions.

Important concessions on the part of the government have recently conferred great advantages upon individual mine owners, and an increased activity in mining operations has been noted as a consequence. Under these new conditions the product of gold in 1877 amounted to 2,430 poods, of which only 155 poods came from the mines of the crown and state; the remaining 2,275 poods came from mines of private individuals; an increase of 437 poods over the product from private mines in 1876. Of the product from private mines in 1877 Eastern Siberia furnished 1,793 poods, Western Siberia 129 poods, and the Ural 353 poods. It is expected, for the same reasons, that gold-mining operations will henceforth become still more active, and the product of the metal will be accordingly greater in the future than in the past.

Increased activity in private mines.

Placer mining principally.

Nearly all the gold produced in the Russian Empire is obtained from placers. Vein-mining for that metal has not been actively prosecuted until recently, and only in the Ural Mountains. In the foregoing tabular statement of the gold product, the quantity of sand and mineral treated during ten years, as expressed in poods, amounts, in the aggregate, to about 184,000,000 tons of 2,000 pounds avoirdupois, and the corresponding product for ten years is valued at $221,576,472, presuming that the weight of gold given is that of fine metal. This would show a yield per ton of about $1.20. To what extent the product of vein-mining figures in this statement does not appear from the data in hand; but as the product of placers so far exceeds that of vein-mining, it is not likely

Amount of sand and mineral treated.

Its product.

RUSSIA.

Mineral wealth. Gold.

that the latter raises the general average yield per ton very much. Recent official data, referring to the placer-washings of the Ural Mountains, show that in that region in 1875 there were extracted 5,300 kilos of gold from 4,240,000 tonnes of auriferous sand, giving an average per tonne of 1¼ grams. This would correspond to about 20 grains of gold, or something over 80 cents per ton of 2,000 lbs. avoirdupois.

Percentage of gold in placer washings of the Ural.

Vein-mining in the Ural.

Vein-mining is carried on in the several districts in the Ural, but apparently to a small extent. The district of Bérésowsk, in which gold-bearing quartz veins have been worked for many years, still appears to be the principal locality for this branch of mining. The formation consists of beds of talcose schists, in which occur broad dikes of beresite, a granitic rock containing pyrites and a little mica. The quartz veins traverse the beresitic dikes perpendicularly, rarely, though sometimes, passing beyond the limits of the dikes, which generally have a width of 60 to 80 feet. The quartz veins are not generally large (varying from a small seam to 3 or 4 feet), and the average value of the ore is low, being stated at 2 to 25 grams to the tonne, say about 30 grains, or $1.20 to four-fifths of an ounce troy, or $16 to $17 per ton of 2,000 lbs. avoirdupois. The average value of quartz veins worked in this district during former years is stated at about 13 grams to the tonne, or, say, half an ounce of metal per 2,000 lbs. of ore.

The geological formation.

Percentage of product.

Platinum.

Platinum.—This metal is generally found with the gold of auriferous sands. It rarely occurs by itself, that is, without gold, though such is the case in one or two districts of the Ural, namely, Taguilsk, Goroblagodatsk, and Bisersk. It has not, so far, been found, at least to any considerable extent, in rock *in situ*, although grains of platinum are said to have been observed in the quartz of the mines of Bérésowsk, and the entire product is obtained from placers, that is, sands resulting from the disintegration of the rocks. The deposits of Taguilsk and Bisersk, in which districts platinum is generally found unaccompanied by gold, are described as follows in the official publication of the Department of Mines. Serpentine and peridotite form the bed and the borders of the platiniferous deposit, and fragments of these rocks predominate among those occurring in the sand. Chloritic and talcose schists also occur to some extent in the material comprising the deposits, together with chromic iron and a certain conglomerate of serpentine peridot and chromic iron, with a calcareous cement.

Usually occurs with gold.

Obtained from placers.

Nature of the bed and border rocks of the platiniferous deposit.

From the occurrence of the metal in grain distributed through the fragments of serpentine and peridotite (from

RUSSIA.

Mineral wealth. Platinum. Serpentine and peridotite the natural gangue of platinum.

which last-named rock the serpentine is believed to have resulted), it is supposed that the platinum originally existed in a state of dissemination throughout these rocks in place prior to their disintegration. This view of the intimate relation of platinum to serpentine is corroborated by the evidence of several examples, as for instance in the district of Miassk, where platinum is found in auriferous sands; the portions most productive in platinum are those which rest upon the serpentine rocks. At the sources of the river Miass, near the Narali Mountains, which are composed of serpentine rocks, the auriferous sands contain considerable platinum; but down the river, in proportion to the disappearance of the serpentine rocks, the quantity of platinum becomes less and less, and finally nothing in places where there are no outcrops of that rock.

Found in grains and nuggets.

The platinum occurs in the form of grains and sometimes in nuggets of greater or less size. The largest nugget so far found weighed about 22 pounds. Platinum is also accompanied by chromic iron, gold, iridium, and ~~iridosenine~~ iridosmine. The average tenor in metal per tonne of the platiniferous sands is from 6 to 8 grams, or about one-fourth of an ounce troy; sometimes it amounts to an ounce and a third. Since the discovery of the platinum deposits in the district of Nijre-Táguilsk, that is, from 1825 to 1877, the product of that metal there has amounted to 67,500 kilos, or 148,810 lbs.

Annual production of platinum in the Ural.

The average quantity of platinum now annually produced in the districts of the Ural is placed at 1,650 kilos, or 3,360 lbs.

The production of platinum during recent years is given in the following table:

Table of platinum production.

Production of platinum in Russia during recent years.

Years.	Number of exploitations.	Quantity of sands washed.	Quantity of crude metal obtained.
		Poods.	*Poods.*
1867	....	11,607,050	109
1868	....	18,070,650	123
1869	6	13,678,700	143
1870	6	9,609,150	119
1871	6	10,440,650	125
1872	5	8,252,900	93
1873	6	7,620,300	96
1874	5	9,954,800	123
1875	7	9,091,000	94
1876	5	10,370,100	96
Product for ten years			1,121
Equivalent in troy ounces			590,296
Annual average during ten years			59,030

RUSSIA.

Mineral wealth. Platinum.

The entire product of platinum is furnished from mines of private individuals, and situated in the northern portion of the government of Perm. The refining of the metal was formerly done wholly in the mints of St. Petersburg, but at present, since the removal of the tax, the principal portion is exported in the crude state.

Silver and lead.

Silver and lead.—The following table shows the production of these metals during recent years:

Table of production.

Years.	Number of mines of argentiferous lead.	Quantity of mineral produced.	Number of silver-reducing establishments.	Number of furnaces employed.	Quantity of mineral treated.	Silver produced.	Lead produced.
		Poods.			*Poods.*	*Poods.*	*Poods.*
1867	......	2,588,404	7	......	2,774,828	1,106	105,917
1868	29	2,873,486	9	120	3,143,608	1,092	100,225
1869	17	3,083,375	8	123	2,400,717	769	65,092
1870	26	2,116,404	10	130	2,066,792	868	100,654
1871	23	2,177,540	9	130	1,892,636	829	107,964
1872	25	1,886,457	8	110	2,134,119	752	74,662
1873	19	1,883,152	7	120	1,906,425	607	57,606
1874	22	2,065,541	7	119	2,079,868	720	81,150
1875	24	1,580,410	8	103	1,839,826	601	66,060
1876	24	2,096,032	7	111	2,146,728	683	71,278
Product for ten years						8,027	830,608
Equivalent in troy ounces						4,226,857	....
Equivalent in tons (2,000 pounds)						....	14,998
Annual average for ten years, ounces						422,686	....
Annual average for ten years, tons						....	1,500

Principal source of silver and lead.

The silver and lead product of the year 1876 came chiefly from Siberia, as shown by the following statement:

Department.	Number of metallurgical establishments.	Product of silver.	Product of lead.
		Poods.	*Poods.*
Tomsk, Siberia	5	616	58,499
Transbaïkal, Siberia	1	41	5,077
Terek, Caucasus	1	26	7,701

Extensive deposits of silver ore rare in the Ural.

According to the published data of the Department of Mines there are no very extensive deposits of rich silver ore known at present in the Ural. Occurrence of silver-bearing veins are described in the official papers referred to, but they do not appear to be extensively worked. It will be observed in the above statement, referring to the year 1876, that no part of the silver product is credited to the Ural.

RUSSIA.

Mineral wealth Copper.

Copper.—The following statement shows the production of copper in Russia during recent years:

Table of copper production.

Years.	Number of mines.	Quantity of mineral raised.	Number of metallurgical establishments.	Number of furnaces.	Quantity of mineral treated.	Production of copper in— Ingots.	Sheets.
		Poods.			*Poods.*	*Poods.*	*Poods.*
1867	......	7,763,783	....	.....	7,734,779	257,317	18,259
1868	229	8,097,155	43	190	7,975,706	268,078	30,949
1869	98	8,028,728	39	250	7,975,706	259,803	21,597
1870	71	6,392,622	39	262	7,190,213	308,440	29,642
1871	77	6,222,759	35	247	6,384,154	260,007	21,277
1872	81	5,931,133	32	225	5,848,795	227,376	15,723
1873	64	5,975,690	25	234	5,191,931	223,282	18,971
1874	77	5,205,185	26	258	4,271,723	199,527	22,190
1875	79	5,515,081	25	235	4,877,556	222,769	29,142
1876	71	6,340,543	23	233	5,394,222	236,452	23,341
Product for ten years						2,463,051	....
Equivalent in tons (2,000 pounds)						44,474	....
Annual average for ten years						4,447	....

Sources of Russian copper.

The sources of the copper product of the empire in the year 1876 were as follows:

Government.	Location.	No. of metallurgical establishments.	Production.
			Poods.
Tomsk	Siberia	1	33,645
Perm	European Russia	4	73,702
Oufa	do	4	37,537
Orenburg	do	1	2,408
Viatka	do	1	546
Ekaterinoslav	do	1	135
Elisabethpol	Caucasus	5	52,903
Tiflis	do	2	4,525
Erivane	do	1	900
Akmolinsk	Kirghese	1	28,126
Sémipalatinsk	do	1	739
Nyland	Finland	1	1,287

Tin.

Tin.—The following data concerning the production of tin are drawn from official sources:

Table of tin production.

Years.	Number of mines.	Quantity of mineral extracted.	Number of metallurgical establishments.	Number of furnaces.	Quantity of tin produced.
		Poods.			*Poods.*
1869	1	213,000	1	2	1,020
1870	1	66,292	1	2	1,030
1871	1	22,909	1	2	475
1872	1	21,445	1	2	263
1873	1	5,936	1	2	130
1874	1	4,596	......	......	....
1875	1	231	......	......	....
Product for five years					2,920
Equivalent in tons of 2,000 pounds avoirdupois					52
Annual average for five years					10.2

RUSSIA.

Mineral wealth.

The whole of the tin product above quoted was furnished from a single mine in the government of Viborg, in Finland.

Cobalt and nickel.

Cobalt and Nickel.—The production of these metals in the Russian Empire during recent years is shown in the following table:

Table of production.

Years.	Number of mines of cobalt.	Number of mines of nickel.	Quantity of cobalt mineral extracted.	Quantity of nickel mineral extracted.	Number of metallurgical establishments producing cobalt.	Number of metallurgical establishments producing nickel.	Quantity of cobalt matte produced.	Quantity of nickel metal produced.	Quantity of nickel oxide produced.
			Poods.	*Poods.*			*Poods.*	*Poods.*	*Poods.*
1867	1	......	5,220	....	1	....	1,306	....	....
1868	1	......	9,000	....	1	....	2,447	....	....
1869	1	......	7,715	....	1	....	1,560	....	....
1870	1	......	1,249	....	1	....	306	....	....
1871	1	......	649	....	....	....	....	....	....
1872	....	......	....	....	....	....	....	....	....
1873	......	1	....	2,893	....	....	....	....	....
1874	......	1	....	28,584	....	1	....	26	106
1875	......	1	....	22,933	....	2	....	136	483
1876	1	1	460	10,850	1	2	188	248	....

Cobalt ore of the Caucasus.

The ores of cobalt were mined and worked in the department of Elisabethpol, in the Caucasus; those of nickel in the department of Perm, in the Ural.

In the Caucasus the cobalt ore is described as occurring in a contact vein, lying upon a mass of magnetic iron. The inclosing rock of the iron deposit is a diorite, and between the iron and the overlying country rock is a small vein of hard green diorite, in which are small nests, bunches, and stringers of cobalt ore (smaltine), mingled with iron and copper pyrites. The vein was originally worked during several years for copper, the cobalt ores being rejected as worthless. The percentage of cobalt, according to analyses of the ore, varied from 17 to nearly 28 per cent. The ore contained little or no nickel. The vein was worked during several years, but the supply of metal having given out and a considerable sum of money having been expended in ill-directed and fruitless prospecting, the enterprise was abandoned.

Ural ores of nickel.

The ores of nickel in the Ural occur in small veins of quartz, traversing schistose rocks. According to M. Hermann it is an hydrated silicate. It contains 18 per cent. of nickel oxide.

RUSSIA.

Mineral wealth. Zinc.

Zinc.—The following table furnishes the official data concerning the production of zinc in the Russian Empire during recent years:

Table of production.

Years.	Number of mines.	Quantity of zinc ore produced.	Number of metallurgical establishments.	Number of furnaces employed.	Quantity of mineral treated.	Quantity of crude metal obtained.
		Poods.		*Poods.*	*Poods.*	*Poods.*
1867	......	1, 150, 400*	4	......	1, 971, 288*	180, 263
1868	10	1, 526, 928*	4	88	2, 111, 676*	198, 259
1869	......	2, 457, 741	4	56	1, 668, 733	221, 328
1870	6	2, 666, 754	3	128	2, 117, 318	230, 776
1871	6	2, 629, 477	4	141	1, 665, 495	166, 581
1872	6	4, 388, 345	3	91	1, 459, 663	188, 144
1873	7	4, 394, 882	3	91	1, 995, 627	206, 037
1874	9	6, 141, 105	3	71	2, 118, 011	251, 811
1875	6	4, 027, 208	3	88	2, 318, 491	243, 280
1876	6	3, 749, 415	3	127	2, 649, 848	282, 198
Product for ten years						2, 168, 677
Equivalent in tons of 2,000 pounds						39, 158
Annual average for ten years						3, 915

*The data from several private establishments are wanting.

Zinc mines of Poland.

The ores of zinc produced in the Russian Empire are mined entirely in Poland. They consist chiefly of carbonates and silicates, associated with brown hematite. They occur mainly in the dolomite beds of the Muschelkalk formation. The principal mines are in the neighborhood of Olkusz and near the boundary line of Silesia. The great zinc-bearing district of Germany is therefore continuous with that of Russia, the division being merely political. The ore occurs in masses and bunches of very variable dimensions, from one to twelve feet wide, and in several instances possessing very much greater thickness. The percentage of zinc contained in the ores is generally from 8 to 14 per cent. A large portion of the ore is obtained from open surface workings. Subterranean mining is carried to a considerable extent, but not generally to any great depth on account of the great abundance of water.

Percentage of metal in the ore.

Value of zinc product.

The value of the zinc product in 1876, already given in the foregoing table, is stated at about 800,000 rubles, about $600,000.

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Mineral wealth. Iron.

Iron.—The following table furnishes official data concerning the production of iron in the Russian Empire during recent years:

Table of iron production.

Years.	Number of iron mines.	Quantity of of ore extracted.	Number of metallurgical establishments.	Number of blast furnaces.
		Poods.		
1867	....	36,849,139	....	....
1868	1,033	41,235,575	137	....
1869	1,165	42,596,508	155	241
1870	1,283	48,763,156	164	245
1871	1,180	48,471,967	153	244
1872	1,270	54,510,434	150	242
1873	1,196	55,047,471	155	245
1874	1,387	57,021,784	157	247
1875	1,346	64,945,155	156	250
1876	1,311	61,735,785	151	254

Years.	Quantity of ore and slag treated.	Production of metal.		
		In pig.	Sundry forms.	Total metal.
	Poods.	*Poods.*	*Poods.*	*Poods.*
1867	37,003,329	14,642,724	2,910,169	17,552,893
1868	43,048,318	16,600,101	3,187,644	19,727,745
1869	43,701,469	16,943,956	3,159,908	20,103,864
1870	48,464,114	18,557,412	3,401,914	21,959,326
1871	48,329,281	18,834,383	3,099,606	21,932,989
1872	52,176,174	21,046,677	3,328,956	24,374,956
1873	51,533,242	19,970,066	3,494,241	23,464,307
1874	51,649,066	19,855,709	3,357,063	23,212,772
1875	55,774,227	22,571,539	3,489,784	26,061,323
1876	59,396,028	23,302,057	3,654,793	26,956,850
Total for ten years				225,347,025
Equivalent in tons of 2,000 pounds				4,068,994
Annual average for ten years				406,900

Of the above product of 1876 there were 25,935,453 poods of charcoal iron and 1,021,397 poods of iron made with mineral fuel.

Sources of iron product of 1876.

The iron product of 1876 was derived from the following sources:

Government.	Location.	Number of metallurgical establishments.	Number of blast furnaces.	Product of metal.
				Poods.
Perm	European Russia	43	71	13,939,453
Oufa	do	8	13	2,467,927
Kalouga	do	14	18	1,317,010
Viatka	do	6	12	1,313,249
Nijni-Novgorod	do	6	10	1,234,065
Ekaterinoslav	do	1	2	1,021,397
Orenburg	do	3	6	704,920
Tambov	do	2	3	238,024
Riazane	do	3	3	208,727
Vladimir	do	2	3	184,760
Olonetz	do	3	3	167,265
Toula	do	1	1	122,935
Vilna	do	2	2	84,777
Orel	do	1	1	62,726
Volhynie	do	3	3	56,000
Vologda	do	2	2	12,131
Radom	Poland	20	28	1,375,203
Pétrokov	do	8	10	341,600

Iron product of 1876, *&c.*—Continued.

RUSSIA.

Mineral wealth. Iron. Sources of iron product of 1876.

Government.	Location.	Number of metallurgical establishments.	Number of blast furnaces.	Product of metal.
				Poods.
Keltzé	Poland	3	4	173, 920
Kuopio	Finland	6	7	609, 966
Abo	do	3	3	306, 777
Saint Michel	do	3	4	249, 390
Nyland	do	4	4	207, 258
Uleaborg	do	2	2	112, 797
Viborg	do	2	2	91, 892
Irkoutsk	Siberia	1	2	161, 110
Ieniseïsk	do	1	1	87, 997
Transbaïkal	do	1	1	71, 100
Tomsk	do	1	1	30, 888

The principal portion of the iron product, as may be seen in the foregoing table, comes from European Russia and the regions of the Ural Mountains. The prevailing ore of those districts is brown hematite. Magnetite is found in very many localities, but is less extensively worked. Carbonate ores are generally of rare occurrence.

The following table shows the production of wrought iron and steel during recent years:

Table of production of wrought iron and steel.

Years.	Wrought iron in bars, rods, and sundry forms.	Sheet iron of all kinds.	Total wrought iron.	Number of steel furnaces.	Product of forged and cast steel.
	Poods.	*Poods.*	*Poods.*		*Poods.*
1867	......	......	11, 457, 645	......	382, 554
1868	10, 513, 860	3, 173, 099	13, 650, 869	707	568, 885
1869	11, 241, 170	3, 204, 941	14, 446, 411	405	439, 970
1870	11, 971, 459	3, 246, 449	15, 217, 908	495	536, 086
1871	12, 420, 096	3, 086, 317	15, 506, 413	372	442, 241
1872	13, 043, 881	3, 324, 595	16, 368, 476	813	511, 727
1873	12, 026, 281	3, 559, 106	15, 585, 387	472	546, 033
1874	14, 301, 375	3, 673, 745	17, 975, 120	711	469, 718
1875	14, 842, 451	3, 705, 208	18, 547, 659	828	789, 253
1876	13, 853, 076	4, 016, 229	17, 869, 305	681	1, 093, 757

Coal.—The official statistics of mineral fuel furnish the following data concerning its production during recent years: Coal.

Table of production of coal.

Years.	Number of collieries.	Quantity of bituminous coal produced.	Quantity of anthracite produced.	Quantity of lignite and bituminous schists produced.	Total mineral fuel produced.
		Poods.	*Poods.*	*Poods.*	*Poods.*
1867	......	19, 613, 026	6, 903, 189	80, 000	26, 596, 215
1868	......	21, 925, 657	5, 455, 141	150, 141	27, 532, 141
1869	248	24, 871, 106	11, 064, 248	800, 794	36, 736, 148
1870	193	28, 661, 490	13, 017, 371	551, 728	42, 230, 589
1871	327	35, 009, 156	14, 190, 455	1, 454, 941	50, 654, 552
1872	348	45, 076, 324	20, 262, 302	1, 684, 116	67, 022, 742
1873	232	44, 537, 625	24, 704, 675	2, 244, 028	71, 486, 328
1874	303	52, 419, 779	23, 714, 063	2, 679, 295	78, 813, 137
1875	504	76, 551, 713	25, 728, 732	2, 067, 622	104, 348, 067
1876	640	76, 210, 736	33, 274, 467	1, 787, 245	111, 272, 448
1876, tons (2,000 pounds)	......	1, 376, 105	600, 823	32, 272	2, 009, 200

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Mineral wealth. Coal. Anthracite, lignite, etc.

The anthracite product in the above table is from the basin of the Donetz. In 1877 the mining of anthracite in the department of Olonetz was commenced. The lignite and bituminous schists come mainly from Southern Russia (Kiev-Elisabethgrad), partly from Poland, and, to a small extent, from the Caucasus and Turkestan.

The product of mineral fuel in 1876 came from the following-named sources:

Sources of mineral fuel, 1876.

Government.	Location.	Poods.
Don	European Russia	41, 964, 529
Ekaterinoslav	do	16, 458, 424
Toula	do	13, 224, 846
Riazane	do	7, 452, 500
Kiev	do	1, 453, 478
Perm	do	1, 075, 567
Esthonie	do	3, 000
Pétrokov	Poland	27, 668, 407
Akmolinsk	Kirghese	872, 623
Kouldja	Turkestan	298, 932
Siv-Daria	do	50, 000
Tomsk	Siberia	294, 976
Littoral	do	122, 166
Kouban	Caucasus	281, 000
Koutaïs	do	52, 000

Petroleum.

Petroleum.—The official statistics furnish the following data concerning the production and distillation of petroleum during recent years:

Table of production and distillation of petroleum.

Years.	Number of artesian wells.	Quantity of crude petroleum obtained.	Number of distillation establishments.	Quantity of oil produced.	Quantity of sundry products.
		Poods.		*Poods.*	*Poods.*
1867		998, 905			
1868		1, 753, 984			
1869		1, 685, 229			
1870	771	1, 704, 455			
1871	697	1, 375, 523			
1872	733	1, 535, 981	62	518, 546	5, 076
1873	636	4, 176, 885	99	1, 254, 441	41, 100
1874	567	5, 208, 710	110	1, 460, 596	56, 487
1875		8, 174, 440	106	2, 227, 704	41, 769
1876					

Sources of petroleum.

The sources of the above product are almost altogether in the Caucasus, a small proportion coming from Southern Russia and the Kirghese district. In 1877 the production of petroleum and the distillation of mineral oil increased largely, the department of Bokou, in the Caucasus, producing 12 million poods of petroleum and furnishing 4 million poods of mineral oil.

RUSSIA.

Mineral wealth. Salt.

Salt.—The official statistics furnish the following data concerning the production of salt during recent years:

Production of salt, 1867-1876.

	Quantity produced (poods).
1867	44,228,075
1868	36,798,253
1869	39,876,926
1870	36,114,580
1871	28,254,530
1872	39,712,311
1873	50,398,710
1874	46,947,518
1875	37,991,399
1876	42,508,217
Product of 1875, equivalent in tons (2,000 pounds)	767,372

Sources of supply.

The principal portion of the salt product is obtained from saline lakes, about one-third from evaporation, and a small portion from rock-salt. Large deposits of the latter are said to have been recently discovered by borings.

Chromic iron.

Chromic iron.—The official statistics show the following concerning the production of chromic iron during recent years. It is mainly derived from the departments of Perm, Orenburg, and Oufa, in European Russia:

Table of production.

Years.	No. of mines.	Quantity of chromic iron obtained.
		Poods.
1867	2	86,877
1868	5	41,084
1869	2	66,831
1870	9	600,024
1871	6	450,973
1872	7	372,549
1873	9	391,809
1874	6	316,561
1875	8	209,848
1876	4	58,167

Graphite.

Graphite.—The official statistics show the following concerning the production of graphite during recent years. Its chief source is the territory of Semipalatinsk (Kirghese district) and the department of Perm:

Table of production.

Years.	No. of mines.	Product.
		Poods.
1867	1	4,000
1868	2	5,168
1873	1	2,000
1874	1	4,178
1875	4	18,500
1876	3	7,100

Sulphur. Production.

Sulphur.—There is one mine of sulphur and one refinery in Poland (department of Keltze). The product of refined sulphur in 1875 was 31,100 poods; in 1876 the product was

RUSSIA.

Mineral wealth. Sulphur. Statistics.

18,379 poods. Exploitations of sulphur have recently been commenced in the territory of Daguestan, in the Caucasus.

The total number of laborers employed in the mining industry of Russia amounted in 1876 to 285,758.

The horse-power of machines employed in 1876 in the mines and metallurgical works of the empire is stated at 65,717.

Condition of the metallurgical industry of Russia.

The metallurgical industry of Russia is far behind the needs of the country. This remark applies, however, more to the extent of its development than to its methods, and more to the quantity than to the quality of the products.

Within recent years an increased activity in metallurgical industry has been noted. The abolition of serfdom in 1861, the expansion of the system of railways, and the increased use of domestic mineral fuel are among the principal causes that have already promoted and are likely still to advance the development of this branch of industry. The administration of the Department of Mines pursues, on behalf of the government, a very liberal policy. A large corps of engineers are employed constantly in visiting the various sections of the empire, studying and mapping the geology and obtaining all available information tending to promote the development of the mineral resources of the country; and competent men are sent from time to time to visit all portions of Europe and America for the purpose of noting and introducing at home any desired improvements in their methods of work.

Liberal policy and administration.

Insufficiency of the output for Russian consumption.

The products of mineral industry in Russia are, in many respects, insufficient to supply the demand, and the importation of metals and minerals generally exceeds their export. To what extent this is true is partly indicated by the following statement of imports and exports for the year 1876:

Table of exports and imports.

	Importation.		Exportation.	
	From Europe.	From Asia.	To Europe.	To Asia.
	Poods.	*Poods.*	*Poods.*	*Poods.*
Platinum	......	....	66	....
Copper	357,644	1,091	12,304	6,622
Lead	1,354,229	9.769	....	240
Zinc	36,724	851	....	105,107
Cast iron (pig)	2,965,032	....	380	....
Wrought iron	8,622,736	4,900	858,546	94,948
Steel	10,320,349	3,164	4,330	10,343
Petroleum	2,622,486	3,193	....	90,354
Salt	17,279,925	696	2,919	13,835
Coal	88,189,206	48,555	34,475	....
	Rubles.	*Rubles.*	*Rubles.*	*Rubles.*
Manufactures in metal	26,825,336	133,952	140,149	293,710
Machines	27,154,897	60,039	127,023	....
Manufactures in gold and silver	510,387	1,344	424,425	1,650

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Among the principal products imported into Russia, according to the foregoing table, are coal, cast iron, wrought iron, steel, copper, and salt. The following statement shows the sources from which those imports were derived in 1876:

Foreign sources of supply.

Countries.	Coal.	Cast iron.	Wrought iron.	Steel and steel rails.	Copper.	Salt.
	Poods.	*Poods.*	*Poods.*	*Poods.*	*Poods.*	*Poods.*
Great Britain	63, 467, 021	1,920, 267	2,987, 677	5, 283, 332	177, 129	4, 690, 004
Germany	22, 606, 138	561, 282	3,469, 666	2, 493, 594	125, 115	7, 024, 501
Austria	1, 054, 384		33, 465		1, 223	
France	90, 097		64, 676	79, 316	22, 736	66, 446
Spain						1, 433, 631
Portugal						597, 311
Sweden & Norway		214, 029	39, 734	35, 206		203, 218
Holland		7, 937	1,250, 933	1, 208, 938	1, 368	
Belgium	1, 220					
Italy	17, 980	48, 303				66, 719
Turkey	415, 232					
Roumania				358, 894		87, 394

VI.

SWEDEN.

SWEDEN.

THE SWEDISH EXHIBIT.

Unequaled show of iron and iron ores.

It was not only in her display of iron and iron ores that Sweden surpassed other countries. The admirable explanatory literature prepared for the occasion under the auspices of the Swedish Government was, on the whole, unequaled. One of the capital volumes distributed in the Swedish pavilion was entitled *Royaume de Suede, Exposé Statistique*, and contains a complete series of papers touching on all the social, industrial, educational, and scientific features of the country, written, too, for the most part, by well-known specialists. It would be a waste of time to attempt any improvement upon the account of the mineral industries of Sweden given in this manual, and the following pages consist essentially of literal translations from it, abbreviated where the original seemed fuller than was needful for the purposes of this report.

Admirable explanatory literature.

The "*Royaume de Suede, Exposé Statistique*," the source of the author's information.

Peculiar geological conditions of Sweden.

Sweden is, so to speak, made up of the extremes of the series of geological formations. The crystalline rocks of the primary formations are, as a rule, immediately covered by the soft beds of the Quartenary epoch, and only a small portion of the intermediate formations are represented. Of these the Silurian covers the greatest area.

The gneiss formation.

Throughout vast regions the country consists of rocks of the primary formations, gneiss alternating with other sedimentary rocks of the same period and even with granite. In Sweden, as in other countries, one grand division of the territory occupied by this rock is composed of red gneiss, another of gray. The gray gneiss extends over most of the eastern portion of the country, the red over the western.

The important eurite group.

Another division of primary origin, probably later than the preceding, consists of the group called eurite or petrosilex (hälleflinta). Although they cover a relatively insignificant territory, these last rocks are of great industrial value, inasmuch as they contain the most important deposits of iron ores, which do not occur as veins, but in beds or lenticular masses evidently formed at the same time with the inclosing rocks. The same is the case with certain of the deposits of zinc and of copper.

Mode of occurrence of iron, zinc, and copper ores.

So far as is known, coal occurs in Sweden only in the extreme southern province in the Malmöhus district. The geological horizon of the coal beds is not definitely determined, but is commonly referred to the Trias or the Jura. They have, however, been worked at long intervals since the middle of the eighteenth century. SWEDEN. Coal.

The greater part of the coal extracted has been won in the neighborhood of Hogänäs, in the northern portion of the field. At this point there are two seams. One of these, varying in thickness from six to eighteen inches, is abandoned; the other is, to be sure, some four feet six inches thick, but contains only about seven inches of good coal and thirteen inches of poor coal, the remainder being composed of bituminous shale partings. Below the coal is a bed of fire-clay about five feet in thickness, which is mined with the coal to some extent. The coal called second quality contains 20 per cent. ash, and the third quality no less than 42 per cent. The quantity of coal mined in 1876 was nearly 3,700,000 cubic feet (or, roughly, 80,000 tons). The production has doubled since 1871. Hogänäs field. Quality of the seams. Fire-clay. Output of coal in 1876.

Active explorations have been going on by boring in the coal district, and to some extent with satisfactory results, several seams, some of them much thicker than that of Hogänäs, having been thus discovered; but usually much of the thickness is shale and clay. The refractory clays are of superior quality, and are extracted in large quantities. Most of the coals are unfit for making coke. Quality of the coal.

The importation of coal and coke, which comes almost exclusively from England, has increased constantly during the last decades. In round numbers the quantity imported was— Imports of coal.

In 1860	12,000,000 cubic feet, or, say, 260,000 tons.
In 1870	21,000,000 cubic feet, or, say, 470,000 tons.
In 1876	38,000,000 cubic feet, or, say, 840,000 tons.

If Sweden is wretchedly off for coal, it at least has abundance of peat. Recent explorations have proved that the peat marshes cover one-twelfth of the area of the country, and that the average thickness of the peat in these marshes is two meters. For the past few years the high price of coal and "the zeal of a number of patriots" have greatly stimulated the raising and application of this fuel to such an extent that at least eight times as much peat is now extracted as in 1865. No official statistics as to the amount of peat raised exist, but it is believed that at least 450 machines for making peat are at work, and that they will turn out an average of 5,000 tons a year each. Several Abundance of peat. Area of the peat marshes. Increased application of peat. Machines and product.

SWEDEN.

Peat machines.

machines are mentioned in the report, but that of Eichorn, which makes the peat into balls, as improved by Horn and Thünberg, seems to enjoy special favor.

United States' interest in the success of the economical applications of peat.

There are districts in the United States where peat is the most plentiful fuel. We have therefore a direct interest in the Swedish efforts to render it a convenient one. No mention is made of the metallurgical application of peat, though it is well known that it is applied, to some extent, in the manufacture of gas for Siemens furnaces.

Use in Siemens furnaces.

Excellent iron ores of Sweden.

It is of course in its admirable iron ores that Sweden possesses its chief mineral wealth. Professor Åkerman contributed a special memoir on the Swedish iron industry to the literature of the Exposition, and by far the greater part of the exhibits related to that metal, with which, however, this report is not concerned.

Copper industry next to that of iron.

Next to iron, copper is the most important metal obtained in Sweden. The most productive copper mines are those of Fahlun and Åtvidaberg, The former is about 120 miles northwest of Stockholm; the latter a few miles nearer, in a southwesterly direction. Copper ores are also obtained in numerous other places in smaller quantities. Lapland has a copper mine at Svappavara, the importance of which has been much exaggerated.

Localities of the copper mines.

Varieties of ores.

The chief ore of copper is chalcopyrite. Variegated copper ore and copper glance are rare. With a view to economizing fuel, which was constantly rising in price, an elaborate ore-dressing establishment was constructed at Fahlun some ten years since, but, in spite of admirable organization, the loss of copper in the ore-dressing operations was too great, and extraction by wet methods was adopted, instead of concentration and smelting. The greater part of the copper is now extracted by chloridizing, roasting, leaching, and precipitation with iron sponge, the copper precipitate being refined in gas furnaces. At Åtvidaberg the old method of smelting is still pursued. The regulus produced by smelting the ore is roasted and reduced to black copper, which is subsequently refined in reverberatory furnaces. The smelting of the ore and calcined regulus is carried out in blast furnaces.

Wet and dry methods.

The present usual process.

The smelting process.

Production.

Workmen.

In 1876 901 tons of copper and 286 tons of sulphate were produced in Sweden. The number of workmen employed in this industry was 1,455. The production of copper has undergone a sensible diminution in the course of late years. It reached its maximum in 1869, when it amounted to about 2,300. Some 350 to 500 tons commonly remain in the country; the remainder is exported. Copper ore is also exported to England. In 1871 this exportation was in the

Export.

neighborhood of 1,500 tons, but had sunk to half this amount in 1876.

Copper.

Copper is worked up in part in the smelting works and in special rolling mills, partly by coppersmiths in town and country, and in part, and that on a large scale, by the great machine shops of the country. The manufacture of apparatus for the distillation of spirits is one of the principal branches of the Swedish copper industry.

Principal application of the copper.

Gold.

Gold is extracted at present only from the copper pyrites of Fahlun, and to the extent of some half-dozen kilos per year.

Lead and silver.

Lead and Silver.—The principal silver mine of Sweden is the old and famous one at Sala. Its production is insignificant now in comparison with its former yield, and in 1876 was only 798 kilos. All the silver is produced from lead ores, and of lead as well as of silver only a very small quantity is now produced—some 300 tons.

Nickel.

Nickel.—Nickeliferous ores are of frequent occurrence in Sweden, but comparatively seldom in paying quantities. The principal mines are at Kleva, in the province of Jönköping, and at Sägmyra, in Dalecarlia. The product consists of an alloy of nickel, more or less rich in copper, of which somewhat less than a ton was produced in 1876. At Tünaberg about a thousand pounds of clean cobalt ore was extracted in the same year.

Zinc.

Zinc occurs only as a blende, of which there are several mines. The most important is that of Ammeberg, which lies between the great lakes Werner and Wetter. It belongs to the famous Belgian company *La Vielle Montagne.* The product of this mine was about 1,300 tons of ore in 1860, but since 1865 the output has been from 25,000 to 30,000 tons. Adding the product of mines in the provinces of Örebro and Kopparberg, the total production for 1876 was 35,523 tons. The ore is concentrated by roasting, leaching, and dressing, and is thus exported. No metallic zinc is produced in Sweden. Manganese, iron pyrites, for sulphuric acid manufacture, etc., and graphite are mined to a small extent.

Mine of Ammeberg.

Production of zinc in 1876.

Metal-working establishments.

Metal working in its various branches is carried on with some activity for the supply of the home market. There are four brass works in the country, several German-silver factories, silver-plating establishments, and the like.

The primitive character of the Swedish rocks.

The greater portion of the surface of Sweden is composed of hard and compact rocks belonging to primitive formations, such as gneiss, eurite, granite, etc., and it is in these rocks that most of the ore deposits are found. In consequence of

SWEDEN.

Prospecting by boring but little practiced.

Investigation by the magnetic needle.

this fact, prospecting by boring has not been so much practiced in Sweden as in some other countries. The position and extension of deposits of iron ore have been for a century, and are still, investigated by the magnetic needle. It is certainly incorrect to speak of this method of prospecting for magnetic ores of iron, as the Swedish commissioners do, as *presque inconnu à l'étranger*. Professor Thalén, the well-known physicist, has lately mounted the needle as an instrument of precision, and has shown how, by a considerable number of observations on the deflections of the needle above a deposit of iron ore, the positive and negative poles of the magnetic mass can be determined. Between these points lies the greater portion of the ore body.

Boring apparatus.

Diamond and other machine drills.

Comparison of machine and hand drilling.

The apparatus most used for boring, where this method is practicable, is that of Mortensen. The diamond drill and the Chinese rope-drill have also been applied. For drilling short holes many machines have been tried. The "Iron Bureau" (*Jern Kontoret*) had a series of competitive trials executed at its expense with the machines of Burleigh, Schram, Rand, Ingersoll, and Cederblom. Our authority reports: "The result of all these trials has been that machine drilling, far from being cheaper than hand work, cost much more in most cases, a circumstance due principally to the astonishing dexterity of our miners." It would be interesting to know something of the size of the openings where the trials were made, etc., in order to gage the extent of our astonishment.

Miners' ladders.

Drainage and hoisting works.

Swedish mining machinery offers no special points of interest. Access is obtained even to the mines at Fahlun (1,200 feet) and Sala (1,100 feet) by ladders only. Little trouble is experienced with water, and pumping and hoisting are commonly effected by power derived from water-wheels, for water-power is more generally available in Sweden than in almost any other country.

VII.

NORWAY.

THE NORWEGIAN EXHIBIT.

The Scandinavian peninsula is a geological unit, and what has been said of the geology of Sweden is, for the most part, equally true of Norway. The deposits of lignite in the southern province of Sweden do not extend into Norway, and the kingdom is practically without coal or lignite. Even the formations where such might be looked for are confined to the portion of the country lying within the Arctic Circle.

Absence of coal and lignite.

The fundamental rocks of Norway are assigned* by Norwegian geologists to the Azoic epoch, in which is included what Hunt and other American geologists call the Eozoic or Archæan, as well as the earlier gneiss. The close of the Archæan period in Norway was marked by eruptions of granite, forming in part ranges of hills, in part irregular masses. These granites are frequently accompanied by *gabbro*,† and possess great importance with reference to the deposits of ore.

As to the geological character of the rocks of Norway.

Immediately after the great topographical changes produced by the eruptions of granite, and possibly while they were still going on, began the deposition of the Taconic beds.‡ These beds rest unconformably on the older strata and are three in number. The second has been identified as corresponding to the Potsdam epoch in the United States. The Taconic beds cover a very large proportion of the area of Norway.

Intrusions and depositions.

Important occurrences of eruptive rock are also met with which are referred to the close of the Taconic era. The eruptive rock is mainly gabbro, but granite, syenite, and diorite of seemingly eruptive character are also referred to the same period.

Eruptive rocks.

The Silurian and Devonian formations occur mainly in two considerable areas, the one at and north of Christiania,

Silurian and Devonian formations.

* *Le Royaume de Norvége et le Peuple Norvégien,* par le Dr. O. G. Broch, p. 106.

† A variety of greenstone; equivalent to the *Fr. Euphotide.*

‡ The Taconic system of Emmons is nearly synonymous with the Lower and Middle Cambrian of Sedgwick and others.

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the other in nearly the northernmost portion of the country. Eruptive rocks are assigned to periods during the Silurian and succeeding the Devonian.

Periods of eruptive rocks.

Four outbursts of plutonic rock are, then, recognized in Norway: An Ante-Taconic, a Post-Taconic, a Silurian eruption, and one in Post-Devonian times.

Absence of certain formations.

Throughout Southern Norway all the formations from the Devonian to the Post-Tertiary are wanting.

Coal seams.

On the little island of Andoe, off the northwest coast of Norway, occur coal seams determined by Dahll as Jurassic. These seams are thin, varying from 4 to 20 inches,* and are at present of no practical value. In Finmark, the northernmost province of Norway, there are also beds of graphite, supposed to be of Carboniferous origin.

Graphite.

The Fahlbands.

The positions of their occurrence.

The connection between the ore deposits of Norway and its geological structure is interesting. Norway is the home of the *Fahlbands*, or the impregnated zones of rock, and these deposits are almost uniformly at or near the contact between the eruptive crystalline rocks and the more or less metamorphic sedimentary strata. Thus to the west and northwest of Kongsberg, at the limits of an Ante-Taconic granite area, occur masses of gabbro. Near the gabbro the adjoining "Azoic" rock contains the famous deposits of native silver and silver ores—veins in *Fahlbands*. The cobalt deposits of Snarum and Modum and the nickel deposits of Ringerike are of the same character. At Ekersund titanic iron ore is found under similar conditions.

Metallic deposits in the *Fahlbands*.

Occurrence of iron and copper ores,

and nickel.

Ores, especially those of copper and of iron, frequently occur at the edge of the Ante-Taconic granite. This is the case with the celebrated iron-ore deposits of Naes, and with copper mines at several points in Telemark and in Saetersdal. The Post-Taconic eruptive rocks, especially the gabbro, are similarly accompanied by ore deposits, particularly of chrome iron, copper, and nickel. The well-known copper deposit at Roeros or Roeraas, in Trondhjem, is of this character. The Silurian and Post-Devonian outbursts of plutonic rocks do not appear to have been accompanied by the deposition of ores; it is, however, from these later occurrences, especially at Grefvenås, near Christiania, that the granite so valuable for ornamental and monumental purposes is quarried.

Auriferous river-beds.

All the considerable rivers of the extreme north of Norway are auriferous. The gold is found in small scales in the river-beds and in the coarse secondary gravel deposits form-

* J. Marcou, *Carte Geolog. de la Terre*, p. 76. Letter from Mr. T. Dahll.

ing the high banks between which these rivers run. From the description given, it seems not impossible that these deposits might be suitable for hydraulic mining were they situated in a more genial latitude.

Auriferous river-beds.

Norway, though a remarkable mineral country, cannot be called a rich one, for the value of the products of the mines and smelting works is not much more than half that of the crude and bar metal consumed in the kingdom, as is shown in the following table:

Inadequacy of the native supply of metals.

Mean annual value of the Norwegian metal trade from 1871 *to* 1875.

Statistics of production, import, and export.

Value of products of mines and smelting works	$1,521,400
Value of crude and bar metal exported	554,932
Value of crude and bar metal retained	966,468
Value of crude and bar metal imported	1,645,756
Value of crude and bar metal consumed	2,612,224

The mining industry of Norway appears to be declining in some important respects. The value of the silver and of the iron produced annually since 1870 was little more than half as great as it was between 1850 and 1855. The copper product has remained very nearly constant. On the other hand, the amount and value of the nickel and the pyrites mines has increased rapidly since 1860, bringing the total value of the mining industry to a slightly higher point than it reached twenty years ago.

Decline of the mining industry.

Increase in the nickel and pyrites product.

The following tables from Dr. Broch's volume exhibit the commercial relations of the Norwegian mining industry:

Product of the Norwegian mines.

Product of the Norwegian mines.

	Mean for the years—		
	1861–'65.	1866–'70.	1871–'75.
Silver ore ... tons*	1,900	2,000	2,190
Copper ore ... do	13,330	16,680	16,610
Pyrites ... do	13,190	65,860	72,235
Iron ore ... do	24,495	20,235	28,235
Cobalt ore ... do	5,875	2,290	3,115
Chromium ore ... do	600	10	90
Nickel ore ... do	3,540	4,560	18,580
Zinc and lead ore ... do	....	3,000	600

*Tons of 1,000 kilos, or 2,205 pounds avoirdupois.

NORWAY.

Product of the Norwegian smelting works.

Product of the Norwegian smelting works.

	Mean for the years—		
	1861–'65.	1866–'70.	1871–'75.
Silver.........tons..	3.3	3.6	3.6
Copper.........do...	522.8	512.9	563.6
Copper sulphate.........do...	3.4	12.9	8.0
Iron.........do...	8,850.0	2,605.0	1,680.0
Cobalt.........do...	16.2	8.2	35.1
Arsenic.........do...	3.2	0.6	0.8
Nickel.........do...	12.6	39.5	110.5

Value of the product of mines and works.

Value of the products of mines and works.

	Mean for the years—		
	1861–'65.	1866–'70.	1871–'75.
Silver.........francs..	720,000	780,000	760,000
Copper.........do...	1,170,000	1,200,000	1,400,000
Pyrites.........do...	380,000	1,970,000	2,320,000
Iron.........do...	1,680,000	1,010,000	890,000
Cobalt.........do...	110,000	60,000	150,000
Chromium.........do..	200,000	....	7,000
Nickel.........do...	140,000	310,000	2,050,000
Zinc and lead.........do..	....	150,000	30,000
Total.........do...	4,400,000	5,480,000	7,607,000
Total in dollars.........	880,000	1,096,000	1,521,400

Kongsberg silver mines.

A considerable number of Norwegian mines exhibited at Paris. The most noted of them all is Kongsberg, so famous for its enormous masses of native silver, and so peculiar from the fact that this silver contains mercury. The Kongsberg mine was discovered in 1623, and opened the next year, under royal auspices, by miners from Saxony.* In 1630 a mass of native silver weighing 400 marks, or 93.5 kilos, was discovered. A large number of mines were opened up, and the number of workmen employed rose to about 4,000. The mines were worked steadily up to the year 1805; but not having paid running expenses after 1770, were shut down. The total production up to 1805 was 561,150 kilos of fine silver.

Discovery in 1623.

Product up to 1805.

Reopening in 1815.

In 1815† the mines were again opened by the Government of the United Kingdom of Norway and Sweden, but upon a smaller scale. Only four mines are now in operation, viz, the Armen (Poor Man's Mine), Kongens (King's Mine), Gottes Hülfe (God's Help), Has Sachsen (House of Saxony). Of these the first is the deepest, and reaches a depth of about 1,900 feet. The hoisting in these mines is performed

* Brückmann, *Magnalia Dei.*, etc., p. 860.

† The *Catalogue of the Norwegian Exhibit*, from which most of this information is taken, reads 1875, a misprint.

by water-power, and the drainage and transportation in part by tunnels.

Kongsberg silver mines.

Treatment of the ore.

The ore is sorted and dressed by machinery. The native silver, containing 87 to 90 per cent. of the metal, is refined by a single operation in a refining furnace, which brings it up to 0.998 or 0.999 fine. The other concentrations are smelted with pyrites and rich slags, and the regulus is desilverized by lead, which is refined.

Large masses of native silver.

The King's Mine (1,870 feet deep) has been the most productive, and large masses of native silver and of argentite are often found there. In 1832 a single mass of silver weighing 500 kilos (worth, say, $20,000) was found; and in 1867 another of the same size was discovered.

Present production.

The present production is from 4,000 to 4,500 kilos of silver yearly, besides 10 tons of copper derived from the pyrites added in the smelting process.

Exhibit of the ores, metal, and workings.

The Kongsberg mines exhibited interesting specimens illustrating the ore deposits, the ores and native silver, and maps of the workings.

Nickel.

Various nickel mines also exhibited. The metal is not purified in Norway, but reduced to an alloy of nickel and copper and other foreign substances, and exported to England or Germany for farther manipulation.

VIII.

BELGIUM.

THE BELGIAN EXHIBIT.

Great mineral wealth.

The territory of Belgium comprises about 11,372 square miles and contains a population of 5,300,000 inhabitants. Taking into account its limited area, it is, in respect to mineral wealth, one of the most favored countries of the world.

Variety of mineral productions.

In fact, it may be said that, excepting certain metals, precious stones, and some other substances of but little real use, the country furnishes all the materials necessary to satisfy the wants of mankind. The extraction of these substances is facilitated also by their mode of occurrence in

Favorable geological conditions.

the rocks containing them. The geology of the country is highly varied, nearly all the important and economically valuable formations being represented among the rocks outcropping at the surface; and it is partly to this circumstance that the great diversity of industries developed in the land is to be attributed.

Coal, iron, lead, and zinc, the principal mineral resources.

Coal, iron, lead, and zinc are of chief importance among the mineral resources of Belgium; but, besides these, there is a great variety of other valuable substances, the products of the earth, such as materials used in construction, in agriculture, in the arts and manufactures, which form the basis of many varied and extensive branches of industry. The following table, which is an abridgment of one presented by M. Cornet, in his paper on the Mineral Industry of Belgium, shows the different useful substances occurring in Belgium, grouped according to the geological formation in which they are found:

Cornet on the "Mineral Industry of Belgium."

Formations and their yield.

Modern formation	Peat. Materials for bricks. Gravel for road metal. Iron ore.
Quaternary	Materials for bricks, Sand. } Construction. Gravel for road metal. Iron ore.
Tertiary	Iron ore. Sandstone for rubble, dressed stone for building, pavements, refractory stones, etc. Sands (construction, ballast, molding, glass manufacture, and other uses).

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Formations and their yield.

Tertiary	Clays for tiles, drainage pipes, pavements, bricks, etc. Concretionary limestones for Roman cement. Limestones (dressed stone for building). Marls for fertilizers.
Cretaceous	Limestones for building. Phosphate of lime (fertilizer). Chalk for manufacture of lime, carbonic acid, etc. Silex for pottery and road metal. Marl. Fuller's-earth. Clays for sundry uses. Sands. Iron ore.
Jurassic	Limestones for sundry uses. Iron ores. Fertilizers. Sandstones.
Triassic	Marls. Hydraulic limestones.
Carboniferous	Coal. Sandstones for various uses. Schists producing alum. Silicious sandstones for road metal. Limestones and Dolomites } for various uses. Lead ores. Iron pyrites. Zinc ores. Barytes.
Devonian	Limestones and Dolomites } for various uses. Sandstones. Iron ores. Zinc ores. Iron pyrites. Barytes. Slates. Whetstones. Grinding stones.
Silurian and Cambrian	Slates. Whetstones. Sandstones for various uses. Cut stones for construction. Sands and minerals used in pottery. Manganese. Manganiferous iron ore.

Coal. The region of its occurrence.

Coal.—A broad and deep valley, formed by a depression of the Carboniferous limestone, traverses Belgium from the southwest to the northeast, passing by Quiévrain, Mons, Charleroi, Namur, and Liège. The rocks of this valley consist of the coal-bearing formations, and along its line from the French to the German frontier active coal-mining operations are in progress.

Depth of the coal-bearing strata.

The depth of the coal-bearing strata, considered with reference to sea-level, varies very much at different points

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along the line of the valley. In the near neighborhood of Namur, in the central line or axis of the basin, the lower members of the coal-bearing formation are exposed at the surface at a height of 650 feet above the sea. From that point the formation is inclined both to the east and the west, reaching its greatest depth or thickness near the town of Mons on the west and near Liège on the east. Beneath the town of Mons the depth of the coal basin is 2,270 meters (7,445 feet) below sea-level. At Boussu, a little farther west, its depth is probably 325 feet greater; and, as the altitude of that locality is about 100 feet above the sea, a vertical shaft sunk at that point would only reach the lowest coal-bearing rocks at the great depth of 7,872 feet. Near Liège the thickness of the coal-bearing formation is also very considerable, and probably exceeds 4,600 feet.

Inclination, depth, and thickness of the coal measures.

The two coal-bearing basins.

By reason of this inclination or dip of the coal formation in opposite directions to the east and the west from the neighborhood of Namur, the coal fields, considered geographically, are divided into two parts—the basin of Liège at the east and the basin of Hainaut at the west. The last named, which is the more important for the production of coal, includes in the mining district of Charleroi that part of the basin which is situated in the province of Namur.

Relation of the number of coal seams to the thickness of the Carboniferous formation.

The number of coal seams occurring at any part of the coal basin is generally proportionate to the thickness of the Carboniferous formation at the part considered. They are accordingly less numerous in the province of Namur and increase in number, both to the eastward and the westward, in approaching the districts of Liége or Mons. In the western basin, where the coal formation has its greatest known thickness, there are from 130 to 160 coal seams, of which about two-thirds are workable. According to André Dumont there are 85 coal seams in the province of Liège.

The formations overlying the coal measures.

In the provinces of Liège and Namur, as well as in a portion of the province of Hainaut, the coal formation is covered only by the alluvial formations of the Meuse and the Sambre or by inconsiderable thicknesses of the Cretaceous, Tertiary, or Quaternary beds. The sinking of mining shafts in those localities is consequently attended by no very serious difficulties. West of Fontaine l'Evêque, in the district of Hainaut, the deposits overlying the coal formation attain a constantly increasing thickness, reaching a depth of 1,000 to 1,300 feet between the town of Mons and the French frontier. To pass through these formations, which contain inexhaustible sources of water and quicksand, some of the

Depth of overlying deposits in the district of Hainaut.

most important and extensive works known in the records of mining industry have been undertaken.

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Rocks associated with the coal.

The rocks of the Carboniferous formation most intimately associated with the coal are schists and sandstones. The former are the prevailing rocks. Generally the coal seam is intercalated between two strata of schist; occasionally the coal is overlaid with sandstone, and sometimes, though rarely, the sandstone forms the floor on which the coal reposes. The relation of the strata to each other is usually as follows:

Schist.
Coal.
Schist.
Sandstone.

Relation of the thickness of coal seams to that of the whole formation.

In general the coal forms less than a one-thirtieth part of the whole material composing the formation.

Thickness of seams.

The thickness of the coal seams varies from a few inches to 8 or 10 feet, but generally the workable seams are from 20 inches to 4 feet thick. Those less than 15 inches are seldom if ever exploited. The workable seams are rarely composed of coal unmixed with other material, but are frequently divided by thin layers of carbonaceous schist.

The following is one of a number of examples representing a vein of average character:

Example.

	Inches.
Carbonaceous schist	2
Coal	15.5
Carbonaceous schist	6
Coal	18.75
Schist	2
	44.45

Length of Belgian coal basin.

The length of the Belgian coal basin, measured along its central axis, from the French to the German frontier is 170 kilometers, or about 106 miles. Its width, measuring its exposure at the surface is variable, as shown by sections at various points named below:

Width.

	Miles.
At the west of Mons, about	8
At the meridian of Charleroi, about	9½
At the meridian of Namur, about	2
At Huy, about	2
At Seraing, about	5
East of Liège	11

Area of workable coal field.

The entire area of the surface exposure of the coal formation of real economic value in Belgium is estimated at 532 square miles, of which total 316 square miles are in the

BELGIUM.

basin of Mons and 216 square miles are in the basin of Liège.

Early use of coal.

The exploitation of coal in Belgium commenced at a very early age. Indeed, notwithstanding the probability that mineral fuel was known and used in China a thousand years before Christ, one of the existing legends concerning the history of coal refers its first discovery to the neighborhood of Liège, in the year 1198, by a smith named Hullos, from whom the name of the mineral *houille* was derived. The coal-mining industry began to assume importance in Belgium in the last century and has since then been almost constantly growing, promoted as it has been by the use of steam-power, first for drainage and later for extraction of coal.

Liège, 1198.

Statistical data commence in 1836.

The complete statistical data concerning the coal industry of Belgium go back only to the year 1836. At that time the annual production of the country already exceeded 3,000,000 tonnes. The annual increase since that period appears in the following table, which shows the production of the several provinces traversed by the coal basin, together with the total production of the country. From 1836 to 1873 the production of coal in Belgium was multiplied fivefold. In the last-named year it reached its maximum. Its diminution since that date is attributed to the general depression of all industry, not only in Belgium but in neighboring countries.

Table of production of coal: 1836–1876.

Coal industry of Belgium.

Years.	Production of coal in Belgium in the provinces of—				Total.
	Hainaut.	Namur.	Liège.	Luxembourg.	
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1836	2, 349, 374	97, 174	627, 916	....	3, 074, 464
1837	2, 469, 605	92, 473	666, 729	....	3, 228, 807
1838	2, 405, 909	103, 954	740, 408	....	3, 260, 271
1839	2, 599, 011	124, 397	755, 753	....	3, 479, 161
1840	2, 951, 781	125, 054	853, 124	4	3, 929, 963
1841	2, 968, 875	122, 777	935, 854	261	4, 027, 767
1842	3, 059, 183	134, 451	946, 902	927	4, 141, 463
1843	2, 874, 453	140, 698	966, 365	758	3, 982, 274
1844	3, 290, 728	134, 008	1, 019, 908	896	4, 445, 240
1845	3, 670, 486	161, 872	1, 086, 045	753	4, 919, 156
1846	3, 798, 335	159, 864	1, 078, 380	823	5, 037, 402
1847	4, 201, 531	158, 307	1, 303, 905	707	5, 664, 450
1848	3, 651, 712	157, 264	1, 050, 170	518	4, 862, 694
1849	4, 018, 195	169, 688	1, 063, 453	507	5, 251, 843
1850	4, 420, 761	177, 306	1, 122, 225	296	5, 820, 588
1851	4, 753, 186	187, 857	1, 292, 099	....	6, 233, 517
1852	5, 234, 646	182, 578	1, 377, 906	....	6, 795, 254
1853	5, 482, 771	185, 504	1, 503, 275	....	7, 172, 687
1854	6, 154, 860	209, 990	1, 582, 790	....	7, 947, 742
1855	6, 458, 416	230, 861	1, 720, 053	....	8, 409, 330
1856	6, 219, 132	218, 609	1, 774, 678	....	8, 212, 419
1857	6, 441, 182	201, 804	1, 740, 916	....	8, 383, 902
1858	6, 885, 011	217, 774	1, 852, 929	....	8, 925, 714
1859	7, 099, 326	220, 850	1, 840, 526	....	9, 160, 702
1860	7, 507, 720	204, 528	1, 898, 647	....	9, 610, 895
1861	7, 935, 645	243, 061	1, 878, 457	....	10, 057, 163

(Continued.)

Coal industry of Belgium—Continued.

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Table of production of coal: 1836–1876 (from former page.)

Years.	Production of coal in Belgium in the province of—				Total.
	Hainaut.	Namur.	Liège.	Luxembourg.	
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1862	7,795,170	246,500	1,893,975	....	9,935,645
1863	8,101,102	255,667	1,998,561	....	10,345,330
1864	8,670,372	266,235	2,221,729	....	11,158,336
1865	9,206,058	305,734	2,328,911	....	11,840,703
1866	9,851,424	358,687	2,564,551	....	12,774,662
1867	9,595,289	389,586	2,770,956	....	12,755,822
1868	9,398,550	310,969	2,589,070	....	12,298,589
1869	9,840,530	303,638	2,798,726	....	12,942,894
1870	10,196,530	338,407	3,162,181	....	13,697,118
1871	10,037,230	350,389	3,345,557	....	13,733,176
1872	11,616,166	389,688	3,653,094	....	15,658,948
1873	11,652,953	450,870	3,674,578	....	15,778,401
1874	10,698,130	440,124	3,530,775	....	14,669,029
1875	10,968,175	491,365	3,551,791	....	15,011,331
1876	10,486,660	474,975	3,367,943	....	14,329,578

Table of population. Extraction, and consumption of coal: 1836–1876.

Years.	Population of Belgium.	Quantity of coal—				Average consumption per inhabitant.
		Extracted.	Imported.	Exported.	Consumed.	
		Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1836	....	3,074,464	22,447	773,612	2,323,299	......
1837	....	3,228,807	28,415	789,083	2,468,139	......
1838	3,972,943	3,250,271	34,703	775,534	2,519,440	0.634
1839	4,013,052	3,479,161	28,363	745,569	2,761,955	0.688
1840	4,054,352	3,929,963	30,424	779,473	3,180,914	0.784
1841	4,092,557	4,027,767	28,962	1,015,194	3,041,535	0.743
1842	4,113,775	4,141,463	35,192	1,014,716	3,161,939	0.763
1843	4,194,093	3,982,274	30,855	1,086,321	2,926,808	0.699
1844	4,258,426	4,445,240	11,449	1,245,399	3,211,290	0.754
1845	4,290,316	4,919,156	9,348	1,543,472	3,385,032	0.790
1846	4,335,319	5,037,402	11,088	1,355,833	3,692,657	0.852
1847	4,345,014	5,664,450	9,930	1,827,105	3,847,275	0.885
1848	4,359,090	4,862,694	9,557	1,460,570	3,411,681	0.783
1849	4,398,016	5,251,843	10,969	1,664,973	3,597,839	0.811
1850	4,469,310	5,820,588	9,397	1,987,184	3,842,801	0.859
1851	4,490,113	6,233,517	9,998	2,057,050	4,186,465	0.932
1852	4,502,912	6,795,254	8,102	1,103,546	4,699,810	1.043
1853	4,548,507	7,172,687	12,845	2,331,595	4,853,937	1.067
1854	4,584,932	7,947,742	53,082	2,625,958	5,374,866	1.172
1855	4,529,461	8,409,330	68,578	2,974,349	5,503,559	1.215
1856	4,539,228	8,212,409	88,709	2,866,137	5,434,991	1.197
1857	4,590,217	8,383,902	146,069	2,877,012	5,642,959	1.229
1858	4,623,089	8,925,714	107,605	3,091,316	5,942,003	1.285
1859	4,671,187	9,160,702	110,069	3,145,235	6,125,536	1.311
1860	4,731,957	9,610,895	97,009	3,450,306	6,257,598	1.322
1861	4,782,255	10,057,163	92,771	3,379,409	6,770,525	1.415
1862	4,836,566	9,935,645	78,817	3,290,595	6,723,867	1.390
1863	4,893,021	10,345,330	72,907	3,329,507	7,088,730	1.448
1864	4,940,570	11,158,336	68,224	4,011,197	7,215,363	1.460
1865	4,984,451	11,840,703	76,044	4,404,488	7,512,259	1.505
1866	4,829,320	12,774,662	187,306	4,865,894	8,096,074	1.676
1867	4,897,092	12,755,822	461,130	4,400,364	8,816,588	1.800
1868	4,961,644	12,298,589	247,749	4,659,000	7,887,338	1.589
1869	5,021,336	12,942,894	239,342	4,606,946	8,575,290	1.707
1870	5,087,105	13,697,118	235,250	3,964,844	9,967,524	1.959
1871	5,113,680	13,733,176	205,838	4,368,287	9,570,727	1.871
1872	5,175,037	15,658,948	221,890	5,630,197	10,250,631	1.980
1873	5,215,823	15,778,401	683,373	5,286,190	11,175,584	2.142
1874	5,265,634	14,669,029	470,514	4,662,896	10,476,647	1.989
1875	5,308,217	15,011,331	720,534	4,965,227	10,766,638	2.028
1876	5,336,185	14,329,578	826,131	4,632,097	10,523,612	1.972

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Considerations from the foregoing tables.

According to the second of the foregoing tables, which shows for a series of years the population of Belgium, the quantities of coal produced, imported, exported, and consumed, and the amount consumed per each inhabitant, it appears that the consumption of coal, which in the earlier years considered did not exceed two and a half million tonnes, or about 600 kilos (1,320 lbs.), per inhabitant, increased in thirty-six years to more than eleven million tonnes, or 4,712 lbs. per inhabitant.

Yield per hectare.

If the coal production of 1873 (the most productive year) had been furnished in equal proportions from all parts of the surface of the coal basin, each hectare (2.47 acres) would have yielded 115 tonnes of coal. The yield per hectare is, of course, not equal, some portions yielding much more than others. In one of the concessions (Bonne Espérance) near Charleroi each hectare of coal land furnished, on the average from 2,500 to 3,000 tonnes of coal annually.

The foregoing tables give an idea of the extent of the coal-mining industry of Belgium, and of its development during past years. The following data refer to the year 1876.

Statistics: Companies, Laborers, Steam power.

In that year 180 companies were engaged in the exploitation of coal in Belgium, employing in the underground and surface works together, 108,543 laborers with 4,668 horses and 1,645 steam engines, the latter classified as follows:

	Horse-power.
335 engines for extraction, with	39,222
365 engines for ventilation, with	12,312
189 engines for drainage, with	31,828
756 engines for sundry uses, with	8,669
1,645	92,031

Depth of shafts.

With the exception of a small quantity of coal produced in the mines that are situated above the level of the valleys and worked by adits, the coal product of the country is raised from vertical shafts. Many of these do not exceed 300 to 400 feet in depth, while some attain a depth of 2,500 feet. In 1875 there were 322 shafts in operation in Belgium, having an average depth of 1,150 feet.

Coal raised in cars on cages.

Style of engines.

The greater part of these shafts are furnished with guides, and the method of extraction is by cages, on which cars are raised from the levels below to the surface. Most of the hoisting engines are non-condensing, some of them having 500 horse-power and upwards. For pumping, condensing engines are generally, but not always, used. Some of these have from 800 to 1,000 horse-power. In some cases the pumps are operated by means of a balance-bob acting upon the pump-rod, but in more instances the power is direct, the piston-rod of the engine being in line with the pump-rod and connected with it. Coal.

Compressed air as a motive power for machinery employed in mines has been in use in Belgium since 1845, and its application is steadily increasing in extent and in variety of uses. Compressed-air engines.

Iron.—The ores of iron worked in Belgium are hematite, limonite, and argillaceous carbonate. The latter occurs sometimes in small quantities with the limonite, and it also occurs independently in deposits, but which are too small to permit profitable exploitation. Iron. Character of ores.

Hematite is found in various forms and in very different geological positions, but it is almost altogether, if not only, in the oolitic form of deposit that it is worked in Belgium. In this condition it forms important deposits in the quartzose schists that underlie the coal measures and crop out on both sides of the valley containing the coal basin. The principal mining operations are on the north side of the valley, where, in the neighborhood of Vedrin, there are four separate strata, having the dimensions of 2¾ inches, 4 inches, 8 inches, and 11½ inches, forming with the intercalated schists a bed of nearly 4 feet in thickness. Hematite. The ore bed of Vedrin.

At Marchovelette there are five strata, varying in width from 4 to 8 inches. At Ville-en-Waret the developments have shown four strata, of which two are from 8 to 20 inches thick, forming with the interstratified schists a group of 23 to 24 feet. At Houssois, near Vezin, at a point where the outcrop turns abruptly to the southwest, the beds of hematite attain a thickness of about 7 feet. The bed of hematite is traversed at several points by veins and faults, at the contact of which the ore and the inclosing schists are often impregnated by pyrites, galena, and other substances which impair the quality of the iron ore. Along the outcrop on the south side of the valley the developments are much less important than on the north. The principal workings on the south are near Huy, where the formation comprises two layers of hematite having a thickness of little less than four feet, separated by a bed of schist of about one foot. Ore beds of Marchovelette, Ville-en-Waret, Houssois, and Huy.

The average yield of the hematite ores is from 35 to 40 per cent of metal. Percentage of metal in the hematite.

The limonite ore also occurs in varied forms and in deposits of very different geological position. In recent form- Limonite ore.

BELGIUM.

Iron.

Limonite ore.

ations it forms beds 6 inches to 3 feet or more in thickness, reposing upon argillaceous sands in the depressions of the surface, and mainly along the borders of the rivers Demer, the two Nethes, and their affluents. The ore from these deposits is concretionary and porous, containing about 40 per cent. of iron. It has much phosphorus, but is easily reduced.

Quaternary limonite of Hainaut.

In the Quaternary formation a silicious limonite is worked near Quévy, in the district of Hainaut, which, mixed with argillaceous sand, forms a bed varying in thickness from 3 to 5 feet, resting in a depression of the Tertiary sandstone. The ore contains phosphorus.

Superficial deposits of Luxembourg.

The isolated and superficial deposits of iron ore occurring in the province of Luxembourg, and notably at Ruette, Athus, Toenich, etc., also belong to the Quaternary formation, resting upon the Jurassic, the ore deposits having apparently resulted from the disintegration of Jurassic rocks in the Quaternary age. It contains about 30 to 45 per cent. of metal.

The iron ores of the Jurassic formation.

The Jurassic formation which forms the surface of the southern part of the Belgian province of Luxembourg and of the grand duchy of the same name, and of the northern portion of Lorraine, is also exceedingly rich in iron ore, and furnishes a large quantity to the Belgian iron industry. The ore from this source is known by the name of *minette*, and is an oolitic limonite consisting of fine grains (from one-third to one-sixth of a millimeter in diameter). The ore occurs in deposits, which are very extensive in the localities just named, but of limited extent in Belgium, forming beds near the French frontier about 5 to 6 feet thick. The ore contains 30 to 45 per cent. of iron. The gangue consists chiefly of carbonate of lime, silica, and a little gypsum, and is very fusible.

The limonite deposits inclosed in the primary rocks.

The primary rocks of Belgium, comprised between the lower quartzose schists and the coal formation, inclose many important deposits of limonite, which, up to the present time, furnish the greater portion of the ore consumed in the Belgian iron industry. These ores always occur in masses or veins—never in stratified form. The deposits are often of large dimensions.

Table of production, etc.

The following table shows the production, importation, and exportation of iron ores in Belgium during a series of years. The notable decline in the production in late years finds its explanation in the fact that the Belgian furnaces are con-

BELGIUM.

Iron.

stantly drawing their supplies of ore (minette) more and more from the Grand Duchy of Luxembourg:

Table of production, importation, and exportation of iron ores: 1850–1876.

Years.	Iron ores.		
	Produced.	Imported.	Exported.
	Tonnes.	*Tonnes.*	*Tonnes.*
1850	367,360	.....	.....
1860	809,176	1,486	152,114
1865	1,018,231	301,846	230,539
1867	603,829	322,891	152,227
1868	519,740	396,282	136,067
1869	628,046	551,900	164,576
1870	654,332	568,571	179,867
1871	697,272	594,405	162,566
1872	749,781	790,593	178,997
1873	503,565	739,541	215,042
1874	527,050	738,835	109,144
1875	365,044	804,370	141,767
1876	269,206	671,134	166,418

Source of imports.

Of the entire quantity of iron ores imported in 1875, 1876, and 1877 about three-fourths were brought from the Grand Duchy of Luxembourg; the remainder mainly from Prussia, France, Netherlands, Spain, and Algeria. The iron ores exported in same years were sent mainly (over 90 per cent.) to France; nearly all the remainder to Prussia and the Netherlands.

Destination of exports.

Table of production, importation, and exportation of pig-iron: 1840–1876.

The following table shows the amount of pig-iron produced in, imported into, and exported from Belgium during a series of years:

Years.	Pig-iron.			Blast furnaces in operation.
	Produced.	Imported.	Exported.	
1840	.....	.....	10,438	.....
1850	144,452	.....	92,345	41
1860	319,943	725	22,086	51
1865	470,767	24,864	10,711	56
1867	423,069	53,385	11,062	
1868	435,754	42,549	16,525	.....
1869	534,319	61,600	14,206	.....
1870	565,234	82,330	10,176	48
1871	609,230	84,299	48,526	49
1872	655,565	137,008	49,096	52
1873	607,373	145,212	27,208	54
1874	532,790	158,291	16,188	55
1875	540,473	146,886	15,672	42
1876	490,508	207,264	9,479	31

The iron industry of the Belgæ in the Roman period.

The iron industry of Belgium is very ancient. In the time of the Romans the inhabitants of the Belgian provinces were noted for their skill and industry, and were well acquainted with the arts of the production and manufacture of the metals. The ruins of two furnaces of that period were discovered a few years ago at Lustin, between Namur

BELGIUM.

Iron. Iron industry in the 12th century. In the 16th century. Improvements about 1800.

and Denant, which threw much light upon the methods of producing iron then in use. In the twelfth century the iron industry had already attained a high degree of excellence in the Netherlands; and in 1560 there were in that country not less than 35 melting furnaces and 85 forging establishments. About the year 1800 great improvements were introduced in the form of furnaces, increasing their height from 15 to 25 feet, and greatly enlarging their productive capacity.

Société John Cockerill. Statistics.

The largest iron and steel establishment in Belgium is that of the *Société John Cockerill*, at Seraing, founded in 1817. It employs 8,750 workmen, aided by 259 steam-engines of 6,600 horse-power. Its daily consumption of fuel exceeds 1,000 tonnes, and its annual production has a value of about 32,680,000 fr., or about $6,500,000.

Lead. Galena. Mode of its occurrence.

Lead and Zinc.—The principal ore of lead mined in Belgium is galena. It occurs only in the older formations, where it is found in veins or in masses, and either alone or associated with zinc blende and pyrites. The gangue of the veins is generally a carbonate of lime, barite, and quartz, with clay and with limonite; in the masses the gangue is commonly a dark clay.

Associates of the galena.

In some places the galena is often accompanied with other lead minerals, such as cerusite (the carbonate), which is quite frequent, and pyromorphite (the phosphate), which is comparatively rare.

Mine at Bleyberg.

Galena occurs in numerous veins in a number of places, many of them too unimportant for exploitation. The principal lead-mining operations of Belgium are in progress in the celebrated vein at Bleyberg, near Moresnet—the only vein in the country which, after having traversed the Carboniferous limestone, penetrates the coal formation. At the line of contact it forms very considerable masses, which, however, are worked with great difficulty, on account of the enormous quantity of water there, involving the necessity of very expensive machinery for its removal.

Zinc. Calamine. Blende.

The zinc ore most important in the production of that metal in Belgium is commonly known as calamine. It is a combination of different oxides of zinc, in which the carbonate, smithsonite, predominates. Calamine, properly so called, that is, the hydrous silicate, is comparatively rare, as also is the anhydrous silicate, willemite. Zinc blende forms also a considerable item in the production of the mines, but its treatment being comparatively difficult it is less sought for than the other ores of zinc. In Belgium the ores of zinc, like those of lead, are found only in the older formations, chiefly the Devonian and the Carboniferous limestone, occurring in veins and masses, associated with galena and pyrites. The localities are numerous, but the most important are in the eastern portion of the province of Liège. The ore there is calamine, generally associated with blende and galena. The ore bodies occur as masses of very considerable dimensions and in various geological positions, but generally at the contact of the Carboniferous limestone and the coal formations. The ores of these masses, which are sometimes hundreds of meters in length and breadth, have a gangue of clay and sometimes limonite, which is worked for iron ore.

Zinc.

Mode and place of occurrence of zinc ores.

In 1876, in Belgium, the lead product was 6,963 tonnes, and the zinc product (crude metal) was 49,960 tonnes.

Product of lead and zinc.

BLEYBERG-ES-MONTZEN.

Bleyberg mines.

The Bleyberg vein is situated in the Carboniferous lime stone and in the Coal Measures, the latter of which overlie the former. The fissure penetrates both and has a general strike northwest and southeast, forming an angle of 57° with the meridian and 115° with the lines of stratification. It has been recognized for a distance of five kilometers in the Coal Measures and of above two kilometers in the limestone. It either stands vertically or dips at an angle of 75° or 80°, sometimes to the east and sometimes to the west. No fault or cross-course has been met with, but it is believed that a change of direction toward the north may be the result of such a phenomenon.

Character and strike of the vein.

The fissure is partly filled with fragments of the country rock. In some places these fragments are entirely surrounded with ore. In others, where the adjacent rock is of a readily decomposable character, the débris has been so closely packed as nearly or quite to exclude the deposition of ore.

Contents of the fissure.

The ores are essentially galena and zinc blende, and of these the zinc blende appears to have been deposited before the galena; for while masses and layers of zinc blende are found free from galena, the masses of galena are invariably mixed with zinc blende. Small quantities of copper, antimony, and silver minerals are also met with. Wherever the interstices between the fragments of wall rock were of any size, the ore exhibits the ordinary banded structure.

Galena and blende.

Order of deposition.

Occurrence of other metals.

Subsequently to the deposition of the ore, calcite quartz and iron pyrites have crystallized out from solution, and now form a portion of the vein matter.

Theory as to the associated crystals in the vein.

BELGIUM.

Bleyberg mines.

Many phenomena make it evident that subsequently to the filling of the veins the fissure has reopened and closed again. This action has resulted in slickensides, the disturbance of the original deposits of ore, and the fracture of the mineral crystals.

Width of metalliferous portion of the vein.

The metalliferous portion of the vein has a total width of 90 centimeters; in those portions of the vein which are densely filled with débris, and in which the walls have given way extensively, the width is much greater.

Vein traverses the limestone and the coal measures.

No difference is perceptible in the mineral filling of the vein between those portions which traverse the limestone and those in which the walls belong to the Coal Measures. At one point in the limestone a cave 500 meters long and 70 meters wide and about the same depth adjoins the vein on the hanging wall. Large quantities of ore of banded structure have been deposited upon the sides of this cave, but the greater portion has been dislodged by violent earthquake shocks, and has rolled down in fragments into the fissure. Enough is left in place, however, to show the origin of what has been dislodged.

Banded ore cave deposits.

Remarkable bedded mass of galena.

At the contact between the limestone and the Coal Measures, and adjoining the vein, a remarkable bedded mass exists. It is supposed that at this point there was a valley, where a sort of lake was formed, which was fed for a long time from springs highly charged with plumbiferous matter. The result was the formation of a large mass of galena without partings and reposing solidly upon the underlying rocks, and was not broken up by the force which reopened the fissure. This deposit is only some 40 meters from the present surface; it is covered with materials originating in the Coal Measures, with various clays, and with Tertiary strata, which are horizontal and lie unconformingly on the limestones and coal measures.

Theory as to the mode of its deposit.

The overlying strata.

Immense flow of water into the Bleyberg mine.

There is said to be no mine where the flow of water is so great as at Bleyberg. The average quantity is 33 cubic meters per minute, but the amount occasionally rises to the enormous figure of 45 cubic meters (nearly 1,600 cubic feet, or 12,000 gallons) after heavy rains or when the snow is melting. The quantity pumped from a depth of 182 meters has been for some years past 18,000,000 cubic meters. This tremendous flow of water is due to the geological conformation of the surrounding country. The mine lies between two ridges in a synclinal, in such a way as to receive the drainage of a large area. The basin is, indeed, in part drained by the river Gueule and its tributary brooks, but wherever these streams pass over porous or broken ground,

Quantity pumped.

Cause of the great inflow of water.

water from them, too, percolates into the mine, and in such quantities that it has been necessary to convert the beds of the streams into canals by covering them with clay held in place by stone flags. Four thousand meters of the river Gueule and 12,000 meters of its tributaries have been thus treated, together 16 kilometers, or about 10 miles.

Bleyberg mine.

Canalization of the Gueule.

The force employed in pumping amounts to 3,300 horse-power, and the annual cost is 500,000 fr. A water-wheel of 12 meters in diameter and 2.68 meters in width, which drives pumps of 60 centimeters in diameter and 1.50 meters stroke, was, up to 1847, the principal engine used in pumping, and still develops a force equal to 90 horse-power. Cornish steam-pumping engines were introduced in 1847, and in 1867 the company had the credit of ordering, and the John Cockerill Company of building, the first powerful rotary engine employed in pumping. This machine is a direct-acting compound condensing engine of 640 horse-power; the fly-wheel with its shaft weighs 52 tons, and the pistons have, respectively, diameters of 1.63 meters with a stroke of 1.25 meters, and of 2 meters with a stroke of 2.50 meters. The pumps of this engine are force-pumps of 65 centimeters in diameter and 2.50 meters stroke. Their capacity is 840 liters per stroke. The engine makes 10 revolutions per minute, and is supplied with steam from 8 Cornish boilers, with two fires each. This first application on a large scale of rotary pumping-engines has been widely imitated. During six years of constant use no accident has happened to the machine, and it has consumed an exceptionally small amount of fuel. The coal, by actual experiment, is only 1.25 kilos per horse-power. Thanks to the good machinery, the mine has not been shut down for an instant for more than 20 years.

Pumping engines.

Annual cost.

Water-wheel superseded by Cornish engine and that by rotary compound condensing engine.

Capacity.

Duty.

The main difficulty in mining, beyond that caused by water, arises from the want of cohesion of the ore in the large ore bodies. These are extracted by cross-cuttings, while in the veins the method is by overhand stoping. There are numerous shafts for hoisting and ventilation, furnished with engines of from 8 to 12 horse-power. In spite of the great danger caused by the enormous quantity of water and the loose character of the ground, accidents are of very rare occurrence, and the number of miners killed amounts to one in 700 each year.

Difficult character of the mining.

Rarity of accidents.

There is a large ore-dressing establishment attached to the mines, employing a force amounting to 45 horse-power and using 800 cubic meters of water per hour. The machinery consists of jigs, percussion tables, etc., as is usual in works of this class, and the capacity is 180 tons of un-

Ore dressing.

Capacity.

BELGIUM.

dressed ore in ten hours. The ore as it comes from the mines contains 18 per cent. of valuable matter. The zinc ore is brought up to a tenor of 45 per cent., the galena to 80 per cent., and the cerusite and the pyromorphite to 65 per cent.

Percentage of value in the ore.

Furnaces.

The Bleyberg Company treats most of its own ores. The zinc furnaces are of the Belgian type, and the lead furnaces those known in mining literature as "Bleyberg furnaces." The loss of fume amounts to almost nothing, and there is no lead colic among the men. The lead is desilverized in the works (process not stated), and the market lead produced is of great purity. The Bleyberg Company is said to have been the first to guarantee the almost chemical purity of its leads, and to sell on the basis of analysis made by both seller and buyer. Hundreds of these analyses might be shown in proof of the excellence of the products. The furnace lead carries only some eight dollars per ton in silver.

Desilverization.

Chemically pure lead.

Production 1853–1878.

Since the organization of the company in 1853 up to the year 1878 the works have produced 59,940 tonnes of lead and 29,934 tonnes of zinc. Over $4,000,000 have been distributed in dividends—about four times the original capital.

Dividends.

Workmens' benefits.

The advantages and inducements to workmen to remain in the employment of the company usual in Europe are given at Bleyberg, and in 1867 the company received honorable mention at the Paris Exposition for their care of the welfare of the miners.

Vielle-Montagne Mining Co.

THE VIELLE-MONTAGNE.

The Vielle-Montagne Mining Company is probably the most famous association of the kind in Europe. It derives its importance not only from the extent of its operations, but from the number of establishments counted among its property, and their wide geographical distribution. The following is a list of the works of the company:

Immense extent and wide distribution of its properties.

In Belgium.

BELGIUM.

Welkenraedt.—Mine of calamine, zinc blende, and lead; ore-dressing works; calcining furnaces.

Angleur.—Zinc foundry and rolling mill.

Tilff (near Liège).—Rolling mills.

St. Leonard (at Liège).—Zinc furnaces.

Valentin-Cocq (station, Jemappe).—Zinc furnaces, zinc-white works, and colliery.

Flône (station, Hermalle).—Zinc and lead mines, blende-roasting furnaces, and zinc furnaces.

Baldaz-Lalore (station, Flémalle).—Collieries and coking furnaces.

Moresnet.—Mines of calamine, ore-dressing works, calcining furnaces, and zinc furnaces.

BELGIUM.

Distribution of properties of Vieille-Montagne Co.

In Germany.

GERMANY.

Borbeck (near Essen).—Zinc foundry.

Oberhausen.—Rolling mill; blende-roasting furnaces.

Bensberg.—Lead and zinc-blende mines and ore-dressing works.

Uckerath (Siegen district).—Mine of zinc blende, lead, and copper, and ore-dressing works.

Mayen (near Coblenz).—Mines of zinc blende, lead and copper, and ore-dressing works.

Wiesloch (near Manheim).—Mine of calamine; ore-dressing works.

In France.

FRANCE.

Asnières (near Paris).—Zinc-white works.

Bray (Euse).—Rolling mills.

Sainte Marie (Oise).—Rolling mills.

Droittecourt (Oise).—Rolling mills.

Viviez (Aveyron).—Furnace.

Panchot (Aveyron).—Rolling mills.

In Sweden.

SWEDEN.

Ammeberg (near Askersund).—Mines of zinc, copper, and cobalt, ore-dressing works, and blende-roasting furnaces.

In Algeria.

ALGERIA.

Hammam and *Aïn-Safra* (province of Constantine).—Calamine mines.

In Sardinia.

SARDINIA.

Various calamine mines, owned wholly or in part by the company, in the district of Iglésias.

The company has, besides, numerous agencies in various countries for the purchase of ores and for the sale of products.

Collective horse-power of engines.

The establishments above enumerated contain 179 engines, representing a collective power equal to about 4,450 horse-power—English.

BELGIUM.

Vielle-Montagne Mining Co.

Table of products, purchases, and sales: 1860–1877.

Table of the products, purchases, and sales of the Vielle-Montagne Mining Company from 1860 to 1877.

[In tonnes of 1,000 kilos (2,205 lbs.).]

Years.	Mines of the Vielle-Montagne.			Purchases of zinc ores, calamine and blende.	Roasting, quantities of ore roasted.	Calcination of calamine, quantities of ore calcined.	Pruduct, crude zinc.	Sheet-zinc rolled.	Zinc-white manufactured.	Sales of zinc and zinc-white.
	Zinc ores, calamine and blende.	Lead ores.	Collieries.							
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1860	47,095	1,268	98,697	31,024	11,670	30,196	28,925	20,847	3,683	26,169
1861	52,009	1,808	97,873	12,243	11,741	33,096	25,691	22,074	3,317	30,849
1862	54,081	1,755	92,959	27,867	18,819	31,841	23,875	21,735	3,885	26,885
1863	51,202	2,010	97,824	29,375	20,863	28,469	27,553	23,303	4,362	33,888
1864	54,640	2,230	89,811	41,094	20,312	26,211	28,115	20,795	4,954	30,582
1865	54,876	2,275	97,912	50,015	30,259	24,127	30,592	21,857	4,860	37,217
1866	53,113	2,261	106,280	37,587	33,528	21,249	31,722	22,054	5,633	37,462
1867	53,362	2,721	97,800	50,175	32,470	22,272	36,260	23,468	5,242	36,083
1868	64,402	2,736	89,816	61,026	28,898	30,669	40,219	24,976	5,419	39,367
1869	67,314	2,499	89,452	57,901	26,603	27,472	42,037	28,216	5,965	44,441
1870	66,426	2,581	96,987	94,494	27,048	35,522	42,112	25,392	5,732	47,108
1871	63,197	3,498	93,913	46,212	26,007	33,925	41,129	36,228	6,849	42,564
1872	63,551	4,165	94,626	78,968	22,276	38,912	39,663	31,102	6,851	43,458
1873	51,824	4,388	87,135	66,026	15,993	30,311	40,295	32,204	5,666	39,539
1874	54,298	4,746	77,338	67,184	20,251	35,414	40,269	31,661	6,041	42,845
1875	53,921	5,329	51,690	69,794	22,066	26,180	41,658	34,990	6,591	43,385
1876	54,569	5,914	78,110	65,161	29,368	16,694	38,518	35,416	4,934	40,194
1877	68,095	6,833	53,499	85,137	32,600	28,440	43,238	35,987	5,689	42,903

BELGIUM.

The following data as to the employés of the company for the year 1877 may be of interest:

Vielle-Montagne Mining Co.

Statistics of workmen, wages, etc.

Average number of workmen employed	7,121
Number of persons dependent on their wages	14,481
Total number of persons supported by wages paid by the company	21,602
Regular wages paid for the year	$1,318,830
Premiums paid for extra good work	$118,877
Total amount paid to hands	$1,437,707
Number of days' work done	2,290,699
Mean salary per head per day	$0.63

Workmens' benefits.

As will be seen from the foregoing table, a considerable sum is yearly expended in the encouragement of excellence in workmanship and of faithfulness in discharge of duty on the part of the men.

Provisions for workmens' residences, sick funds, recreations, etc.

The wages paid are low, but the men enjoy a number of facilities not offered by American mining companies. The company provides quarters, commonly cottages with gardens attached, at very low rates, and encourages the purchase of these houses on a very favorable installment plan. It also contributes largely to hospital insurance funds, to the support of schools and of churches, and even aids in the support of various clubs, musical societies, etc. In short, a systematic effort is made to attach men permanently to the service of the company.

Note on the deposit of zinc ore and the smelting works at Moresnet.

Moresnet.

Deposits of calamine. Kelmisberg.

The deposit of calamine of Altenberg or Kelmisberg belonging to the Vielle-Montagne lies in the lower part of the limestone strata of the Carboniferous formation. This limestone is for the most part converted into dolomite. It occupies the extremity of a zone which simulates a basin raised toward the surface on one side and buried on the other. At the place where the metalliferous deposit occurs it reaches a width of 600 meters. This basin of dolomite and ore is in its turn inclosed in soft dry Devonian schist, which rises on both sides of the basin. A bed of quartzose dolomite, carrying large quantities of water, separates the two rocks. This bounds the dolomite formation and the whole deposit with remarkable regularity.

Geological occurrence.

Deposit of rich and pure carbonate.

This ore, which is composed, toward the surface, principally of carbonate of zinc of great purity and richness, and without a trace of lead or zinc blende, has filled the basin thus raised on one side nearly full, and crops out on the surface to a very considerable extent.

BELGIUM.

Vielle-Montagne Mining Co.

Formation of Kelmisberg.

The formation of Kelmisberg, which is entirely surrounded by dolomite, does not anywhere come in contact with other rocks, and must be considered as resulting from *the slow and gradual change of the inclosing rock into ore by an exchange of bases*. It cannot possibly be considered as a deposit of secondary origin, such as many of the contact deposits of the country unquestionably are.

This remarkable deposit was most largely developed towards the surface; its length may have reached 450 meters, and its breadth from 100 to 150 meters.

Theory of the mode of deposit.

The whole of the hollow formed by the basin at the surface appears to have been filled with ore, or with rock impregnated with metalliferous salts. The most highly concentrated and most remarkable portion of this ground is situated at the northern extremity of the basin, and is almost entirely separated by a projecting point of dolomite from what is known as the southern body. Toward the southwest the deposit is continuous, but is hidden under the dolomitic rocks. It has been followed to the considerable depth of 110 meters, and it is between this level and a depth of 75 meters that the actual workings are being carried on. The filling, that is to say, the metalliferous substance, appears to have been very different at the surface from what it is in depth. While at the surface the ore was nearly pure carbonate, lower down it was mixed with hydrated silicate, which gradually increased until at a certain depth it came to form the larger portion of the ore. Anhydrous silicate, willemite, so characteristic of the Kelmisberg deposit, has always been found in large masses, of a hundred cubic meters or more, scattered without any rule in the mass of the other ores, and completely surrounded by them.

Change in the character of the ore at lower depths.

First workings in the 15th century.

The first shafts are said to have been sunk in the northern deposit, in the fifteenth or sixteenth century. Without any knowledge of the metal which the ore contained, the brass-founders at Aix-la-Chapelle and its neighborhood used the mineral in its crude state. From ancient times and up to the beginning of the nineteenth century, when the Abbé Dony constructed the first furnace for the reduction of zinc (1806), the amount of ore taken from the deposit at its croppings was inconsiderable. The work done after the beginning of this century was no doubt more thorough, but it was not until 1846 that regular or serious operations were begun.

Use by brass-founders of the crude ore.

Abbé Dony's furnace of 1806.

Regular proceedings in 1846.

Yield of 1855.

In the year 1855 the yield was probably the greatest which had ever been taken from a metalliferous mine of this

BELGIUM.

description. It reaches the figure of 137,000 tons of ore as it came from the mine, or 50,900 tons of concentrated ore; the northern deposit was the ore principally worked by former generations, but it yielded a large amount of ore as an open cast between 1846 and 1856, when the bottom of the basin was struck at from twenty-five to thirty meters below the surface. It is estimated that in all no less than 1,500,000 tons were thus removed up to 1856.

Vielle-Montagne Mining Co.

Yield of mines of Kelmisberg up to 1856.

From the year 1856 on, the workings have been entirely underground, and have embraced both the north and south ore bodies. The whole quantity of ore extracted from these deposits is known to amount to at least 200,000,000 tons, representing about a million and a half tons of first-class tenor and quality. The ore-dressing works were built in 1850, and since that time have been brought to the highest state of perfection, and are almost altogether automatic; 200 tons of material can here be treated in ten hours, and yield above 80 tons of concentrations. For some years past the ores from the ancient waste-dumps and those from the newer workings have been separately treated.

Subsequent yield of the workings.

Ore dressers.

Capacity.

The smelting works handle only the ores from this locality. These are for the most part very refractory, being mixtures of silicate and carbonate, and are often at the same time very fusible, from the presence of double silicates of lime and alumina. These two circumstances make reduction very difficult, for it can only take place at very high temperatures, which are accompanied by the formation of slag and consequent losses.

Smelting works.

The furnaces employed are on the Belgian system, and contain 130 tubular retorts each.

Furnaces.

The works possess four blocks of furnaces charging 2,400 kilos of ore, reaching an average production of 850 kilos of metal, with a consumption of 3,300 kilos of coal per 24 hours, of which 20 per cent. is lean coal and the rest bituminous.

Capacity.

It is at the works of Moresnet exclusively that the almost chemically pure zinc is produced which is employed in making *blanc de neige* and for art-castings.

IX.

AUSTRIA-HUNGARY.

AUSTRIA-HUNGARY.

THE AUSTRO-HUNGARIAN EXHIBIT.

Source of the information: Dr. H. F. Brachelli.

The following outline of the present condition of the mining industry of the empire is made up of material presented in the official catalogue of the Austrian exhibit and gathered by Dr. H. F. Brachelli.

Greaty variety of ores in the Empire.

The Austro-Hungarian Empire is exceedingly rich in ores and technically valuable minerals, and is not surpassed by any other state in Europe in respect to their variety. A greater development of the mining industry of the country is, however, most desirable.

The number of persons employed in this branch of industry and the results for 1875 were as follows:

Table of workmen and product; 1875.

	Austria.	Hungary.	The empire.
WORKMEN.			
At the mines ....number..	83, 581	} 42, 391	136, 410
At smelting works ....do...	10, 438	}	
At the salt works ....do...	8, 805	1, 192	10, 797
Total	102, 824	44, 383	147, 207
VALUE OF PRODUCT.			
Mines ....florins..	42, 800, 000	} 19, 700, 000	87, 700, 000
Smelting works ....do...	25, 200, 000	}	
Salt works ....do...	20, 600, 000	10, 200, 000	30, 800, 000
Total	88, 600, 000	29, 900, 000	118, 500, 000

Assumed value of the florin.

These values appear to be given in paper florins, which fluctuate slightly in value. From the value of the silver product mentioned in Dr. Brachelli's essay I have calculated that the florin, as used by him, is equivalent to \$0.4435, while the value of the silver florin is \$0.4878.

The eminent domain of the crown.

All mineral deposits of technical value are property of the crown, and prospecting and exploitation can only be undertaken with the permission of the mining authorities, whose duty it is to see that all mining operations are carried out according to law. A large proportion of the most valuable mines in the empire are owned and worked by the state.

AUSTRIA-HUNGARY.

The principal results of the mineral industry in 1876 were as follows:

Mineral products of the Empire in 1876.

Mineral produce of Austria-Hungary in 1876.

	Austria.	Hungary.	The empire.
Gold ......kilos..	14	1,890	1,904
Silver ......do...	25,166	22,784	47,950
Quicksilver ......do ..	375,400	23,100	398,500
Iron ...... tons*..	273,046	127,379	400,425
True coal ......do...	4,934,335	636,991	5,571,326
Brown coal ......do ..	6,933,382	884,139	7,817,521
Salt ......do ..	249,465	120,115	369,580
Copper ......do...	442	1,025	1,467
Lead and litharge ......do...	7,529	2,419	9,948
Zinc ......do...	3,979	567	4,546
Tin ...... do...	207	....	207
Graphite ......do...	12,717	....	12,717
Petroleum ......do ..	1,064	1,967	3,031

*Of 1,000 kilos or 2,205 lbs.

Besides these a number of others might be enumerated, such as ores of cobalt, nickel, manganese, arsenic, bismuth, antimony, and uranium, and some others.

Occurrence of minerals and metals:

A few words on the distribution of the valuable minerals may be a not unwelcome addition to the table.

Gold. Silver. Quicksilver. Iron.

Gold is found in notable quantities only in Hungary and Transylvania, *Silver* in the same countries and in Bohemia; *Quicksilver* almost exclusively at Idria in Carniola, but deposits occur in Carinthia, and a small quantity is obtained in Hungary from tetrahedrite. *Iron* is found and smelted in almost every province of the empire, but Styria leads in this branch, and produces over a quarter of the whole.

Coal and lignite.

Coal, both true and brown or (in part) lignite, is found in large quantities in the northern portion of the empire, in Bohemia, Moravia, Austrian Silesia, and Galicia. Hungary also produces some coal, but the southern provinces are badly off for fossil fuel.

Salt.

Salt is found in enormous and uncontaminated deposits in the Carpathian Mountains and is also won by solution in great quantities in Salzburg.

Copper: lead. Zinc. Tin. Graphite. Petroleum.

Copper is found chiefly in Salzburg; *Lead* in Bohemia, at Pribram, while in Carinthia, Villach is a famous lead-producing locality. *Zinc:* Western Galicia, Carinthia, and Carniola produce zinc, and the Tyrol must now be added, as will appear in this report. *Tin* is obtained only at one or two spots in Bohemia (Zinnwald, etc.). *Graphite* comes mostly from Bohemia, but is likewise obtained in Moravia and Southern Austria. *Petroleum* is found in Galicia, as are also the paraffin minerals, but not nearly in sufficient quantities to supply native consumers.

Mining has been dull of late years in the empire, except in the collieries, which have increased their output largely,

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owing chiefly to the large exportation of brown coal, which is however partially balanced by a large importation, mostly of Prussian coal.

Coal.

Coal.—The development and extent of the coal production of Austria-Hungary may be seen from the following table, in tonnes: *

Output of coal: 1860–1876.

Years.	True coal.	Brown coal.	Total.
1860	1,948,189	1,548,306	3,496,495
1865	2,836,884	2,232,419	5,069,303
1870	4,295,775	4,060,169	8,355,944
1871	4,969,980	5,078,058	10,048,038
1872	4,788,455	5,767,612	10,556,067
1873	5,171,189	6,732,884	11,904,073
1874	5,096,659	7,183,098	12,279,757
1875	5,185,234	7,666,812	12,852,046
1876	5,564,331	7,798,255	13,362,586

* *Kohle und Eisen*, by J. Pechar.

Relative greater increase of lignite production.

It is a remarkable fact, and one of great importance to Austria, that, as may be seen from the figures, the increase in the product of lignite is much more rapid than that of true coal. This is a consequence of the rapid increase in the production of the lignite fields of the Erzgebirge, which yield brown coal of a peculiarly good quality. Austria, to be sure, has no true-coal fields to be compared with those of England or Westphalia. On the contrary, the coal fields are of small extent, with the exception of that of Kladno-Schlan-Rakonitz, and are, moreover, frequently of such a character as to be worked only with difficulty; the quality of the coal, however, is for the most part excellent, especially for coking.

Coal fields limited,

but of good quality.

Localities of the coal.

The Austrian true-coal fields lie for the most part on an east and west line, beginning at Pilzen, on the Bavarian frontier, and reaching to Galicia, on the Russian frontier; there is, however, also coal in the east and southeast of Hungary, in the Fuenfkirchen and Styerdorf basins.

The lignite deposits.

The lignite deposits of Austria are inexhaustible and easily worked. This fuel is not alone excellent for household use, but answers the purpose of many branches of industry, for raising steam, etc. It has even been used in iron blast furnaces.

The lignite fields of the Erzgebirge;

The most important lignite or brown-coal fields extend along the southern slope of the Erzgebirge. The output from this district is greater than that from any other in Austria, and was 4,800,000 tonnes in 1876. Other less extensive brown coal districts lie between the spurs of the Alps, especially upon their eastern slope in Steyermark and Carniola; finally, there are deposits of brown coal in Hun-

and elsewhere.

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gary and Transylvania. That of the Zillthal is said to be particularly promising. The following shows the relations of the Austro-Hungarian coal trade:

Table of importation, exportation, and consumption of coal.

Years.	Importation.	Exportation.	Consumption.
	Tonnes.	*Tonnes.*	*Tonnes.*
1860	240, 128	279, 675	3, 456, 948
1865	366, 488	385, 662	5, 050, 129
1870	927, 119	925, 198	8, 357, 865
1871	1, 363, 974	1, 046, 501	10, 365, 511
1872	1, 587, 800	1, 167, 401	10, 876, 466
1873	1, 785, 266	1, 681, 029	12, 008, 310
1874	1, 627, 355	2, 160, 812	11, 746, 300
1875	1, 627, 942	2, 703, 237	11, 776, 751
1876	1, 574, 575	2, 734, 862	12, 202, 299

Explanation of the terms "importation" and "exportation":

This table requires some comment. While in the tables representing the coal trade of most European states "importation" means importation from England, this is not the case with Austria. The political boundaries between Germany and Austria pass through the coal region of Central Europe. Silesia, in Prussia, and Galicia and Moravia, in Austria, form, properly speaking, one true-coal field, and the brown-coal regions of Bohemia are more or less continuous with those of Saxony. Accordingly, there has been a lively trade in both species of mineral fuel across the German line ever since the railroad communication between the countries was established. The importation of coal in the table represents almost exclusively Silesian coals, and the exportation Bohemian brown coal carried to Germany.

the mutual traffic between Silesia and Bohemia.

Purposes for which coal was consumed in 1875.

The following table shows the purposes for which coal was consumed in 1875, so far as it has been possible to ascertain them:

	Per cent.
Railways	15.5
River boats	2.0
Manufacturing	55.0
Household and trade consumption	27.5

Workmen employed in Austrian coal mines in 1876.

The number of persons employed in the coal mines of Austria (excluding Hungary) in the year 1876 was as follows:

	Men.	Women.	Children.	Total.
True coal	32, 968	2, 680	735	36, 383
Brown coal	24, 238	1, 780	252	26, 270
Total	57, 206	4, 460	987	62, 653

AUSTRIA-HUNGARY.

The number of steam-engines in use in the coal mines of Austria, again excluding Hungary, in 1876 was as follows:

Steam-engines in use in Austrian coal mines in 1876.

	Hoisting.	Pumping.	Hoisting and pumping.	Total.
True-coal mines	187	175	37	399
Brown-coal mines	229	198	48	475
Total	416	373	85	874

Austrian ore-mining exhibits.

Several of the Austrian mines made instructive exhibits illustrating the geological occurrence of deposits and the methods of mining and smelting the ores.

Report on Austrian mines exhibiting in Paris.

In addition, an excellent account of the exhibiting mines was prepared for the occasion, and sold at a merely nominal price. This pamphlet is entitled *Notice sur quelque-unes des principales mines de l'état Autrichien*, and it is believed that the purposes of this report will best be served by translating literally the greater portion of this authorative and well-digested description, with occasional omissions or abbreviations.

Pribram.

Pribram.

Its position.

The town and mines of Pribram are 51 kilometers southeast of Prague, upon a table-land some 500 to 600 meters above sea-level, which is crossed by low ranges of hills.

History.

It is not known when mining began at Pribram. Concessions to reopen the mines were granted in 1527, since which time they have been worked more or less actively. But it was not until the greater part of the mines became state property, at the end of the eighteenth century, that the era of their real prosperity began.

Geological occurrence of the metalliferous deposits.

The metalliferous deposits of Pribram are veins which occur in the lower beds of the Silurian formation of Bohemia, the "*étage A*" of M. de Barrande. The rocks are principally sandstone, quartzites, conglomerates, and schists, bounded to the east and west by granite and a thin stratum of primary slates of M. de Barrande's "*étage B*." These latter rest conformably upon the older slates. Next come the sandstones of the Grauwacke, which in their turn are covered by Grauwacke slates of a mean thickness of 1,000 meters. Above the Grauwacke lie the sandstone and quartzite forming the extreme limit of the metalliferous deposits. All these beds have a strike of from 60° to 75°. Between the sandstone and the higher Silurian strata to the west of Pribram and of the Birkenberg occurs a fault of great length and of some centimeters in thickness, which is filled with dark gray clay. The strike of this fault is very constant—N. 56° E. Its dip is 75° N.

Pribram.

Numerous metalliferous veins and dikes of diorite cross the lower Silurian strata. Most of the veins show gossans at the croppings, and are filled with argentiferous galena only at the depth of 100 meters and more. The thickness of the veins now being worked varies from a few centimeters to six meters and over. Besides galena, the veins contain black-jack or zinc-blende—poor in silver—iron spar, and often calcite, ruby silver, and tetrahedrite, while argentite and native silver are rarely found. The galena occurs in stringers, or in veins, or in lenticular masses, or disseminated in the compact and quartzose gangue. Many veins have been explored for a long distance, both in the strike and dip, without showing any decrease in richness or sensible variation in the gangue; on the contrary, it may be affirmed that the thickness and the contents in silver increase with the depth.

Nature and contents of the veins.

Almost all the veins now being worked appear in the Grauwacke, many of them pinching and growing poorer towards the surface, as they enter the more tenacious strata of this formation, while the contents of other veins are enriched in the upper portions in spots, or in the line where they enter the Grauwacke. Some of the veins cross the fault above mentioned, and have been recognized at a great distance in the schists on the other side of the fault.

Character of the veins.

There are nineteen shafts at Pribram, which are connected at various levels. The deepest is at Adalbert, which has reached the depth of 1,020.1 meters and has thirty levels. It is the deepest perpendicular shaft in the world. At the thousand-meter level a station for magnetic observations is established. The underground workings also communicate with one another through the great drainage-tunnel "Joseph II," which is 21,906 meters long. All the water of the mines is raised to the level of this tunnel, which is 445 meters above sea-level. The total length of thegalleries is 245,089 kilometers.

The workings.

The great drainage-tunnel.

The exploitation is effected through the shafts and galleries, which latter are driven at vertical distances of from 50 to 70 meters, and from a system of levels. The sinking of the shafts goes on constantly, and powder or dynamite are used in the operation in conjunction with machine drills. By this method of exploration thirty-five veins have been discovered, of which the Adalbert is the principal, not only in its regularity and permanence in strike and dip, but in

Exploitation.

The Adalbert vein.

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the grade of its ores. Finally, several isolated aggregations and feeders running into the walls of the veins have been found, and most of them are workable.

Mode of working.

The ore is almost always extracted by overhand stoping, exceptionally by underhand stoping. The country rock being for the most part strong, there is scarcely any timbering in the galleries. When a drift cuts through weak strata, it is temporarily timbered, and subsequently walled.

Mining cars.

The haulage is performed in "Hungarian dogs" (small, three-wheeled buggies) and cars running on rails, of which there are 37,125 meters laid in the mine. For some years past the haulage has been effected at the Adalbert Mine by horses, one animal drawing from 4 to 6 cars, each containing about 900 kilos of ore.

Compressed-air engines.

In the underground workings of a certain depth hoisting engines are employed, which are run by compressed air from a compressor above ground, and at a distance of about 1,000 meters.

Hoisting cages.

In the large shafts the hoisting is effected on cages by cast-steel wire ropes, made on the premises. For the deeper shafts the rope is tapered toward the lower end. The motors are almost altogether steam-engines. The miners go down and come up either on cages or man-engines, rarely on ladders.

Man-engines.

Annual production.

The annual production is—

	Tons.
Ore requiring sorting	4,000
Ore requiring crushing	60,000
Ore requiring dressing	145,000
Mixed ores	1,000

Sorting.

The first hand-picking is done underground. The high-grade ore is hoisted separately to grass, where it is resorted and passed on to the smelting works; 3,000 tons of smelting ore are thus obtained, with a mean contents of 65 per cent. lead and 0.45 per cent. silver.

Dressing.

The mechanical dressing (stamping, crushing, settling, classification, and separation by water) takes place in four large mills, distributed so as to reduced transportation to a minimum.

Breakers, stamps, settling tanks.

These mills are furnished with rock-breakers, stamps, settling tanks, and a very complete array of ore-dressing machinery. The writer of this report noticed in visiting the works that lateral and terminal percussion tables and continuous jigs were the machines most employed in the final concentration. The favorite material for the lateral percussion tables (Rittinger's Stossherd) seemed to be cast iron, planed smooth. California stamp-batteries were introduced

Percussion tables and jigs.

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Pribram.

some time since, but were abandoned again for the old style "on account of the rapid wear of the cams." This is an experience not readily accounted for by those who are familiar with these batteries on the Pacific slope.

Concentrating mills.

The water for the concentrating mills is furnished by four large reservoirs, with a total capacity of 2,250,000 cubic meters. The annual product of these mills is—

	Tons.
Smelting ore	5,800
Blende	600
Spathic iron ore	90

Steam-engines.

The fixed steam-engines supplying mines and mills with power number 34, with an aggregate of 1,579 horse-power, besides water-power equivalent to 274 horse-power, and a number of steam pumps, hammers, portable engines, etc.

Smelting works.

The smelting works are provided with all the apparatus necessary to work up the products of the mines, of which the *Notice* gives only a list.

Roasting furnaces.

The method of smelting is what is known as the "Commeru process" in Germany; *i. e.*, the galena is roasted in large reverberatory furnaces in which the ore is gradually moved towards the fire. In front of the fire-bridge it is melted down in order to decompose lead sulphate by silicic acid, and get the roasted product as a slagged mass, which is broken into lumps. The ore so prepared is smelted in high furnaces of the Pilz type, only a trace of regulus being found in addition to the lead. The latter is desilverized and the argentiferous lead refined. This process is applicable in Pribram on account of the freedom of the ores from copper.

Smelting furnaces.

Desilverization.

Workmen employed.

The workmen employed in the mine number 3,500, in the ore-dressing works 1,000, and in the smelting works 400.

Workmen's beneficiary institutions.

The Pribram Mine has a mutual insurance fund which provides pensions for workmen no longer able to earn their living and for widows and orphans. Medical treatment and medicine, and in some cases assistance and money, are also furnished out of the fund, which amounts to 370,321 florins, or, say, half as many dollars. It is controlled by a committee elected by the workmen. Its revenue consists in drawbacks from wages and payments made by the works, which amount to one-half those made by the men.

Increasing product.

The *Notice* gives the production of Pribram for 100 years. Less will serve the present purpose. The product is rapidly increasing, and there has been a net profit every year since 1818

Pribram exhibit.

The exhibit made by Pribram included sections of views, samples of ores of different grades, products of ore-dressing

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Pribram.

processes, furnace products, wire ropes, maps and plans, and surveying and magnetic instruments.

Product of the Pribram Smelting Works.

Production: 1860–1877.

Years.	Fine silver.	Litharge.	Lead.	Profit.
	Kilos.	*Kilos.*	*Kilos.*	*Florins.*
1860	12, 807	858, 256	340, 684	119, 298
1865	14, 286	1, 384, 004	369, 650	227, 720
1870	15, 390	797, 410	1, 065, 978	757, 204
1871	16, 274	1, 627, 956	500, 990	634, 429
1872	16, 824	1, 605, 263	641, 194	495, 527
1873	18, 053	1, 904, 302	939, 464	693, 415
1874	20, 351	2, 333, 926	1, 054, 330	683, 761
1875	22, 857	2, 846, 116	967, 670	774, 728
1876	23, 750	2, 868, 638	962, 119	981, 002
1877	27, 015	3, 466, 306	1, 292, 125	1, 288, 722

Joachimsthal.

Joachimsthal.

Position. History.

The little town of Joachimsthal lies on the south slope of the Erzgebirge (Metal Mountains) of Bohemia, in a ravine running north and south. Mining began there, in all probability, during the first years of the sixteenth century. In 1517 the number of miners was 8,000 and the town counted 20,000 souls. It was in 1518 that the first silver crowns were struck here. They were at first called *Joachimsthaler*, afterwards, by abbreviation, *Thaler*, whence also *dollar*.

Depressing effect of the wars of the 17th century.

The wars of the seventeenth century had a highly prejudicial effect upon the exploitation, which declined to such an extent that the annual production sank rapidly from a mean of 22,000 kilos of silver during the first 80 years to an average of 3,000 kilos, at which it remained from 1595 to 1877.

Geological occurrence of the metalliferous veins.

The vein-bearing rocks of Joachimsthal are mica schists inclosed by granite. The veins in the eastern portion of the mine, where there are masses of included limestone, carry calcite as the gangue mineral. Those in the western part of the mine are quartzose, and are accompanied in part by masses of included porphyry. There are seventeen veins which strike north and seventeen which strike east. It is a remarkable fact that those which strike north show enrichment where they pass or cross the intruded limestone or porphyry, while the other set of veins are not thus affected. The width of the veins varies from two meters down. They have been explored to a depth of 520 meters and to a horizontal distance of from 1,500 to 4,000 meters.

Nature of the ores. Workings.

The ores raised carry silver, cobalt, nickel, bismuth, and uranium. There are four shafts, the deepest being 533 meters. The drainage is accomplished by the aid of two tunnels, with a united length of 40 ~~kilos~~ kilometers. About 600,000 kilos of ore are raised yearly.

Joachimsthal. **Concentration of ores.**

Compared with those of other mines the ores raised at Joachimsthal seldom require stamping. The ore is concentrated on Rittinger's percussion tables. The result is 4,000 kilos of concentrations, containing from 0.1 to 0.5 per cent. silver, 5 to 6 per cent. cobalt and nickel, and 8 per cent. bismuth; and, farther, 2,500 kilos of uranium concentrations, containing 24 to 30 per cent. of uranoso-uranic oxide.

Destination of the silver and uranium ores.

The concentrations containing silver, etc., are shipped to Freiberg. The uranium ores are delivered to the local factory, where they are converted into pigments much employed in glass and porcelain coloring. The production of colors amounts to 4,500 kilos yearly, and samples were exhibited in Paris. As a subsidiary product vanadates are also prepared and were exhibited.

Production of colors.

Idria.

Idria.

Position.

Idria, in Carniola, lies above twenty miles east of north from Trieste. The deposit of cinnabar at Idria was discovered between 1490 and 1497.

Geological occurrence of the cinnabar.

Recent investigations of the geology of Idria by the present manager, M. Lipold, have proved that the ore-bearing rocks are exclusively Triassic, and that the Carboniferous sandstones and schists which form the roof of the metalliferous Triassic beds have assumed this abnormal position only by dislocation, displacement, or reversal.

The direction of the principal fracture of dislocation can be studied above ground. It runs from northwest to southeast for a long distance, and is encountered again in one of the principal faults of the mines, and in the extensive fractures and folds of the metalliferous *Wengen* beds which occur in the northern part of the mine.

Geological association of the deposit.

The nature of the deposit is very different here and in the southeast portion. While in the former the deposit is inclosed in the Upper Triassic Wengen beds, which are calcareous conglomerates and dolomitic breccia, and there assumes the form of a segregation or of a bedded vein, in the southeast the ore is contained in limestone and dolomite belonging to the Lower Triassic. Here it occurs especially in transverse fissures filled with schistose limestone and impregnated with cinnabar. This impregnation is observed even in the country rock, in which it occurs in remunerative quantities. The richest ores assume a lenticular shape, and are found in the Wengen beds in the northwest. Their appearance has ~~carved~~ earned for them the names of "steel ore"

AUSTRIA-HUNGARY.

Idria.

(Stahlerz), "liver ore" (Lebererz), and "brick ore" (Ziegelerz). They sometimes contain as much as 40 per cent. of quicksilver.

Workings.

The workable region at Idria is 300 meters deep, 800 meters long, and from 20 to 60 meters thick. At the end of 1877 there were 925,800 cubic meters of rock in sight, with a contents of 32,580,000 kilos of quicksilver. The cubic meter of rock in place gives an average of 2,600 kilos of roasting ore, with a contents of 1.35 per cent. quicksilver.

Winning.

Winning the ore is accomplished by "cross-cut work," a modification of pillar and stall work, involving filling, which is applied to thick seams on ore bodies of great dip and feeble tenacity. Drifts are run at various levels in the ore body, and cross-cuts are run at intervals to foot and hanging wall. The pillars thus formed are won in from the cross-cuts toward the center, and from the walls of the deposit toward the central drift, by side stopes or stalls. To sustain the roof, timbers are set and immediately packed. After the whole level has been stoped out in this way the ore immediately overlying the exhausted stopes is opened out and won in the same manner.

Filling.

The filling is obtained from workings driven for prospecting purposes, from the barren rock won with the ore, or if necessary is even sent down from the surface.

Sorting in the mine.

The ore is divided in the mine into roasting ore, sorting ore, and waste.

Exploitation.

There are five shafts, varying in depth from 100 to 307 meters. The hoisting engines are for the most part hydraulic. The tramways under ground measure 4,000 meters, those above ground 2,900 meters.

Annual production.

The mean annual production is 1,800 metrical tons roasting ore and 28,200 tons of ore requiring sorting; or, in all, 30,000 tons, with a contents of 500 tons of quicksilver.

Sorting at the works.

Hand-picking of the poor rock was substituted in 1842 for a primitive wet dressing. The ores raised are dumped into a screen which separates the coarse stuff from the fine. What does not go through the screen is carried to a sorting house, where it is classified into high grade, low grade, crushing ore, and waste. What goes through the first screen falls into a second and finer screen. What goes through the second screen is delivered to the smelting works direct, and the comparatively small stuff which does not pass the second screen is sorted. The ore, high grade or low, is

Stamps.

crushed dry in a 25-stamp battery, and afterwards delivered to the reduction works separately.

Blake crusher.

The finer ores are reduced in a Blake crusher, then sifted,

Sorting table.

and the coarse stuff sorted on a revolving sorting table into ore and waste. The contents of the various classes of ore is from 0.4 per cent. to 50 per cent. AUSTRIA-HUNGARY.

The methods employed in the extraction of the quicksilver from the ores have varied greatly since the mine was first worked. At first open vessels were used,* afterwards earthen pots, for which cast-iron receivers were substituted in 1641. These receivers at first approximated to the form of jars; in 1665 they were made as retorts. It was at this time that the method of heating the cinnabar with lime was invented. In 1750 the Almaden furnace was introduced. In 1787 the horizontal furnace, called the Idria furnace, with a chimney and condensation chambers, was built.

Idria. Retorting. Lime process. Furnaces.

The great quadruple furnace called the Leopold, and erected in 1825, was derived from the last mentioned. It was at work till 1870. The Alberti reverberatory furnaces date from 1842. They are provided with inclined condensation pipes, cooled by sprinkling with cold water. In 1869 lime kilns were adopted as a type, and two cupola furnaces provided with condensation chambers were erected. This system was perfected in 1870 by M. Exeli, manager of the works and the inventor of the "iron-clad furnaces." At the same period reverberatory muffle furnaces with 8 muffles were constructed for the treatment of the rich ores. In 1871 these furnaces were replaced by the two muffle furnaces now in operation. Since 1875 the reduction of the ores of both high and low grade has also been accomplished by the help of long reverberatory furnaces of the type in use in lead works for roasting purposes (*Fortschauflüngsöfen*).

Leopold furnace. Alberti furnace. Exeli's iron-clad furnace. Muffle furnaces. Reverberatories.

The reduction of cinnabar in muffle furnaces is effected by decomposition of the sulphide by caustic lime. In all the other furnaces it is simply a process of roasting and distillation.

Processes of reduction of cinnabar.

A system of flues of a total length of 706 meters stands in connection with a high stack placed at the summit of the mountain, through which the gases escape, leaving the quicksilver behind.

Fume flue.

The following is a list of the furnaces in use:

List of furnaces in use.

Alberti reverberatory furnaces, heated through the bottoms, condensation in forked pipes	10
Roasting furnace, with bottom heat and condensation in forked pipes	1

* The "*Notice*" says *meules ouvertes*. I suppose this to refer to the *tertia ratio* described by Agricola. Open vessels of ore were placed in a tight room over furnaces heated from the outside. To promote condensation green boughs were placed in the inclosed space. The quicksilver gathered on the floor and the leaves.

AUSTRIA-HUNGARY.

Idria.

Furnaces.

Cupola furnaces, condensation in forked pipes	2
Iron-clad furnaces, the stack heated with wood, condensation in crockery pipes	3
Muffle furnaces	6

Ore production.

In a run of eleven months the works can reduce 13,000 tons of ore in lumps, 20,000 tons of gravelly ore, and 2,000 to 3,000 tons of pulverized ore.

Loss.

The loss has been determined during the last years at 13.58 per cent.

Vermilion.

Vermilion is manufactured on a large scale at Idria. The process is very old, but satisfactory, and consists—

Process.

1st. In the preparation of æthiops by intimate mixture of mercury and sulphur.

2d. Transformation into cinnabar by distillation.

3d. Conversion of cinnabar into vermilion by grinding and washing.

Production.

Sixty tons of quicksilver are annually converted into vermilion in this way, with a loss of 0.35 per cent. of metal.

Workmen.

The workmen employed at Idria number 1,040, of whom 602 are occupied in the mine, 65 in the ore-picking houses, 195 in the smelting works, and the remainder in various shops.

Wages and benefits.

Besides their wages, which are small, the miners receive grain and fuel at a fixed price, and when ill are provided with medical attendance and medicine free of charge. There are also government lodgings for the employés. The mutual insurance association possesses a fund of 78,000 florins, and disposes of a hospital. The mine supports a school for the children of the miners.

Cinnabar exhibit of Idria.

Idria exhibited cinnabar in its various associations and specimens illustrating the geology of the mine; also characteristic fossils of the important beds, very necessary to the proof of so extraordinary a fact as the occurrence of the Triassic under the Carboniferous. The various vermilion colors and the intermediate products in their manufacture were also displayed:

Product of Idria smelting works.

Product of the Idria Smelting Works.

Years.	Length of run, in months.	Quicksilver.	Artificial cinnabar.
		Kilos.	*Kilos.*
1860	Nine	166, 346	78. 117
1865	Ten	169, 329	100, 811
1870	Twelve	370, 690	98, 819
1871	Ten	375, 789	33, 605
1872	Eleven	383, 495	66, 498
1873	do	377, 387	46, 983
1874	do	372, 135	48, 041
1875	do	369, 729	58, 064
1876	do	372, 413	49, 265
1877	Ten and a half.	380, 200	64, 080

Schneeberg.

AUSTRIA-HUNGARY.

Schneeberg.

Another mine mentioned by the *Notice*, and which also exhibited in Paris, is worthy of mention because of its exceptional character and its considerable commercial importance.

Position.

The Schneeberg (Snow Mountain) lies about 30 miles southwest of Innsbruck, and forms the intersection of several lofty ranges. Near its summit, 2,200 meters above sea-level, and just below the glacier limits, is the Schneeberg zinc-blende mine. Everything leads to the belief that this mine was worked as far back as the middle of the fifteenth century—not for blende, of course, but for argentiferous galena and chalcopyrite. In 1486 a thousand miners were at work; but soon afterwards the ore was practically exhausted.

History

Formerly worked for argentiferous galena.

In 1868 and 1869 new examinations of this mine led to its reopening for the sake of the zinc blende found in untouched veins, and also in the ancient pack and on the dumps.

Reopened for blende.

The deposits occur in micaceous schists, which constitute the rock of the range to which the Schneeberg belongs. They are from 2 to 17 meters thick, and consist of blende, galena, and a little iron and copper pyrites. Ankerite, calcite, quartz, garnet, and amphibole, in part in fibrous varieties, accompany the ores. The strike is northeast, the dip 29° to 38° northwest, and the deposits have been followed 2,200 meters in strike and to a depth of 987 meters. The veins are repeatedly faulted.

Geological occurrence of the metalliferous deposits.

The underground work has thus far been confined to general exploration and preparatory arrangements. Extraction on the outcroppings, on the other hand, has made great progress, and large quantities of blende are now obtained.

Workings.

There are three concentration works connected with the mine—two of them close to it, the third at Meiern. On account of the altitude, the works at the mine can only run four months in the year; the establishment at Meiern nine months. The difficulty of exporting the ore is excessive.

Concentration works.

The Schneeberg Mine, with its ore-dressing works, is now turning out about 7,000 tons of blende, with a mean zinc contents of nearly 45 per cent.,* besides over 3,000 tons of dressed galena. It is expected that this product will be doubled or trebled when the projected preliminary work is completed.

Production.

Schneeberg exhibited maps and ores.

* This would give over 3,000 tons zinc. Great Britain produced 6,834 tons of that metal in 1877

X.

ITALY.

Interesting exhibit of Malfidano zinc mines and Roccatederighi copper mines.

While the Italian exhibit was in many respects interesting, the explanatory information presented cannot be said to have been altogether satisfactory. The important mines of Sardinia were well described in a pamphlet issued by the Malfidano Company, and two other mines of comparatively small importance, the lignite mine of Murlo and the copper mine of Roccatederighi, both in Tuscany, pursued a similar course. But the lead and iron industries were represented only by specimens of products, and the information given in the *Catalogo Generale Sezione Italiana* was of the most meager description. The following fragmentary account of the mining industry of Italy must therefore suffice.

Inadequate exhibit of lead and iron industries.

Large exportation of ores in consequence of the absence of coal.

An important part of the mineral industry of Italy * is reflected in the exportation, because in the absence of important deposits of coal the smelting of ores in the kingdom is much limited. The principal exportation of ores during the year 1877 was as follows:

Exportation.

	Tons.
Iron ores	236,667
Copper ores	9,616
Lead ores	27,531
Zinc ores	78,255
Manganese ores	7,375
Sulphur ores	210,327

Carrara marble quarries.

The quarries of Carrara also represent an annual production of about 140,000 tons of marble, which is in great part worked up in the country before exportation.

Salt.

Government monopoly.

Salt is produced both by government works and by private industry. The government, which has a monopoly in all the continental provinces, derives therefrom an income of 80,000,000 of francs yearly, and has nine salt works in operation.

Rock-salt and maritime evaporating works.

These are in part rock-salt mines and in part evaporating works on the coast, and produced from 2,500 to 150,000 tons.

Manganiferous iron.

Manganiferous pig, in part for use in the manufacture of Bessemer steel, is indeed produced, but the whole product is only 30,000 tons per year. Including the reworking of scrap-iron, the production of bar-iron amounts to 50,000

* *Catalogo Generale.*

ITALY.

Importation of iron.

tons. The importation of iron exceeds 200,000 tons annually.

Production of copper and lead.

About 300 tons of copper and 10,000 of lead are annually turned out. In the immediate neighborhood of Genoa there is a lead-refining works, and shops for the manufacture of utensils and of ornamental work in various metals are distributed over the whole kingdom.

Coal.

*Coal.**—As has already been remarked, Italy is poor in mineral fuel. Bituminous coal is found only in the province of Udine, in Sicily, and even this deposit is of no importance.

Very limited supply.

Neither are the anthracite deposits of Italy of much value. The best known is in the valley of Aosta, Piedmont, from which, however, scarcely 500 tonnes (of 1,000 kilos) are yearly extracted. Lignite of Tertiary age is however more plenty.

Lignite fields.

The most extensive lignite or brown-coal fields are in Tuscany, ~~Ligmien~~ Liguria, in the provinces Vicenza, Verona, and Bergamo, and on the island of Sardinia.

Area.

The total area of these coal fields is 13,500 hectares, = 51 square miles.

Peat.

There are, besides, tolerably extensive deposits of peat at the foot of the Alps.

The extent of the output of brown coal is apparent from the following figures:

Output of lignite.

	Tonnes of 1,000 kilos, 2,204 lbs.
Average of the years 1866–1870	70,000
For the year 1871	84,000
1872	95,500
1873	110,305
1874	121,855
1875	101,640

Peat product.

The peat product amounts to about 95,000 tonnes yearly.

Picked specimens of fuels analyzed in the laboratory of the Royal Technical Institute in Florence gave the following results:

Analyses of lignite and peat.

Description.	Locality.	Specific gravity.	Carbon.	Hydrogen.	Oxygen.	Ash.	Units of heat.
Lignite	Montebamboli	1.32	73.44	6.15	13.20	5.10	7.485
Do	Tatti	1.66	73.10	5.88	15.89	2.50	7.220
Peat	Ghedi	......	55.60	6.72	33.83	2.80	5.353
Prepared peat	....do	1.28	50.00	6.80	32.43	8.77	4.978

It is plain that in spite of the very moderate consumption of fuel in Italy the importation of coal must reach considerable figures.

* *J. Pechar, Kohle und Eisen.*

ITALY.

The imported coal comes almost exclusively from England, in what quantities appears in the following table:

Table of importation and exportation of coal.

Italian trade in coal, in tonnes of 1,000 *kilos.*

Years.	Importation.	Exportation.
1866	524,042	1,879
1867	515,943	2,068
1868	580,388	3,934
1869	653,694	6,442
1870	941,789	11,456
1871	791,589	12,550
1872	1,039,724	5,902
1873	959,532	4,189
1874	1,032,035	4,778
1875	1,059,816	7,736
1876	454,542	5,794

Iron.

Large deposits of excellent quality.

Smelting with charcoal.

Iron.—If Italy possessed coal in proportion to the quantity and quality of her iron, she would take rank with the great iron-producing countries of the world. In the absence of coal the iron industry is of little importance and advances but slowly. Smelting is effected almost exclusively with charcoal, and it is more profitable to export ore than to smelt.

Iron ores.

IRON ORES.

Production, importation, and exportation: 1850–1876.

Table of the production, importation, and exportation, in tonnes of 1,000 *kilos.*

Years.	Production.	Importation.	Exportation.
1850	64,000	....	....
1860	71,000	....	....
1866	145,000	392	18,110
1867	105,000	6,578	31,562
1868	102,000	6,263	24,513
1869	101,000	1	54,122
1870	74,000	1	40,711
1871	72,000	7	45,322
1872	167,000	45	168,472
1873	260,000	431	151,949
1874	265,000	12	203,397
1875	234,000	....	191,157
1876	248,000	53	197,697

Localities of the iron mines.

Elba.

Historical iron mountain.

Verrucano mine.

Iron mines are worked in the Lombardic provinces of Bergamo, Brescia, and Como, in Sardinia, and in the Piedmontese provinces of Turin and Novara, but the most fruitful mines are those of Elba, and to them is due the credit of the greater part of the production recorded in the foregoing table. The inexhaustible iron mountain of Elba has been celebrated from the earliest times, and was worked by the Etruscans and the Romans. The ore is shipped at the harbor of Rio, in the neighborhood of which lies the Verrucano Mine, the most important in the island.

Since 1872 the production of iron ores in Italy has been tolerably large, and in the last two years the exportation has been four-fifths of the output. The exported ore goes mainly to France, but a few ship-loads go as far as the United States.

Iron ore.

Mines of Malfidano, in Sardinia.

Zinc mines of Malfidano.

The change brought about in the zinc industry by the reopening of the ancient mines of Sardinia and Greece is familiar to all who have to do with that metal, and information concerning these resuscitated mining districts will be welcome to many. Accordingly, a large part of the *Notia*, published by the Zinc Mining Company of Malfidano, is here reproduced.

Ancient mine.

The deposits worked by the Malfidano Company are of two general descriptions. For the most part they partake of the character of bedded veins. This is the case at Malfidano, at Genna-Arenas, and at Planu-Sartu. But sometimes they are masses or chimneys of ore, which appear to bear no relation to the stratification of the inclosing limestones, except that they preserve the same dip, which is more or less nearly vertical, as at Planedda and at Monte-Rexio. The limestones are supposed to be Silurian.

Character of the metalliferous veins worked by the company.

The most important of these deposits is that of Malfidano, which contains calamine, blende, galena, and cerusite. These minerals are mingled without any order in the deposit. Calamine, however, predominates and constitutes seven-eighths of the whole.

The deposits at Malfidano.

The deposit of Malfidano takes the form of an immense vein, parallel to the stratification of the limestones. Its limits have not yet been precisely determined.

This vein appears to have two branches. In the more important of them the calamine is generally distributed in masses or chimneys, which are parallel to the limestone beds. These chimneys or masses of ore exhibit very variable horizontal dimensions, and sometimes attain a thickness of twenty meters. When several of them unite, as is not infrequent, the ore is developed in the general direction of the deposit for a hundred meters, or even more. Elsewhere the calamine is distributed more regularly in veins of varying thickness. In both modes of distribution the ore follows the general dip.

Distribution of the calamine vein.

It is in this branch of the vein that the mine of Malfidano, properly so called, is situated. The other branch contains few workable deposits.

The deposit at Planedda has the form of an inverted truncated cone, the larger base reaching the surface, where it presents an area of about 1,200 square meters. At 60 me-

Deposit at Planedda.

ITALY.

Zinc mines of Malfidano.

Mine at Planedda.

ters from the surface the area is about 110 square meters, below which there is no ore of any importance. This mass seems to have been nearly worked out. The ore is principally earthy calamine, but of remarkably constant composition, carrying from 39 to 43 per cent. of zinc.

Monte-Rexio mine.

In the deposit of Monte-Rexio are found various concentrations of calamine, occurring in masses of varying size in dolomite limestones. The mass bearing the name "*De la Route*," is the most important; it measures 100 meters by 30, and has been explored for 50 meters in depth without reaching its inferior limit. It consists, for the most part, of white calamine, which is nearly pure carbonate, and of yellowish calamine covered with crystals of zinc silicate. The ore is mixed with lime-spar ferruginous matter, containing a small amount of zinc. The ore of this mine, like that of Planedda, contains little or no metallic sulphides.

Character of the deposit.

Genna-Arenas mine.

The Genna-Arenas Mine, to the west of Monte-Rexio, has not been worked to any great extent. It consists of lenticular bodies, sometimes isolated and sometimes connected by veins of calamine.

Planu-Sartu mine.

The Planu-Sartu claim contains two deposits, distinguished as the north and south bodies. Next to Malfidano the south body is the most important and richest of the deposits belonging to the company, and it is the most regular of all. Its general strike is north 25° east, and its croppings extend for 340 meters, and are from 40 to 50 meters wide.

Character of the deposit.

At the surface the ore forms a series of lenticular bodies, arranged like a string of beads, and were very profitably worked. But in depth the walls of these ore bodies approached each other, whence it was believed that the deposit of the Planu-Sartu would give out. But explorations by shafts proved that below the croppings there are veins of considerable thickness and great regularity, such as are seldom found in deposits of calamine. All these veins are parallel to the limestone beds in which they are situated, and are remarkable for their continuity in depth. Five of these veins have been discovered, and their thickness varies from 1.5 meters to 5 meters. At some points they open out to a greater width, and one of these enlargements reaches 12 meters. The character of the ore of this mine is very varied. The color is white, yellow, red, and black, and the texture varies as greatly as the color.

The north body is parallel to and analogous to the south body, but carries comparatively little ore.

Exploitation.

Exploitation.—The mines of the Malfidano Company seem to be exceptionally well situated for working, for a large part of the ore lies at or near the surface, while at the same time the topography is such that tunnels can be run into the ore bodies. Hence, the deposits can, for the most part, be worked as open casts, and the material dumped through chutes to the tunnels, through which it is brought to the surface nearly at sea-level. Underground workings of the ordinary character are also necessary in a few places. There is little trouble with water.

ITALY. Zinc mines of Malfidano.

Workings.

Production of ore.—The ores extracted are divided into two great classes, lump ore and earthy ore. The latter come almost exclusively from Planedda and Planu-Satu. The production of lump ores, from the organization of the company, has been as follows:

Classification of ores.

Production of lump ore.

	Tonnes.
1866–'67	28,753
1868	35,967
1869	33,963
1870	16,287
1871	15,290
1872	26,878
1873	29,073
1874	31,459
1875	35,119
1876	42,364
1877	45,598
Total	340,756

1866–1877.

In addition, there have been produced, during the same period, 59,102 tons of earthy ore sufficiently rich for sale. An ore-dressing works is being constructed at Buggerru for the treatment of a couple of hundred thousand tons of low-grade ore now on hand, and will go into operation at the end of 1878.

Works for dressing earthy ore.

Besides the ore above mentioned, 21,250 tons of zinco-plumbiferous ore has been sorted out from the products of the mines. The following is given as the mean composition of the ore actually extracted from the Malfidano Mine:

Zinco-plumbiferous ore

	Per cent.
Carbonic acid and combined water	26.40
Zinc	40.00
Oxygen	10.06
Silicic acid	5.00
Lead	5.54
Ferric oxide and aluminum	6.50
Lime and magnesia	4.40
Sulphur	2.00
Total	99.90

Analysis.

This composition is nearly the average of the ores from the various mines, which contain from 38 to 45 per cent. of

ITALY.

Zinc mines of Malfidano.

Analysis.

zinc. The earthy ores are of a similar composition. The zinco-plumbiferous ores contain 34.50 per cent. zinc, 20.50 per cent. lead, and 150 grams of silver per ton of ore.

Exploitation.

These latter, as well as the earthy calamines, are sold raw, while the lump ores of zinc are roasted at Buggerru, with charcoal, in shaft furnaces 6 meters high and 3 meters in diameter at the widest point.

Calcining.

The calcining increases the zinc contents of the ore to 54.40 per cent., and it is said that the variation in the composition of the roasted calamine does not amount to 1 per cent.

Workmen.

The number of workmen employed by the company is 1,465.

XI.

SPAIN.

SPAIN.

Grand natural resources in lead, quicksilver, copper, iron,

So far as natural resources are concerned, Spain is one of the first mining countries in the world. It leads all countries in the amount of lead and quicksilver produced; the copper-mining district of Huelva is one of the most important in Europe; the iron mines of Bilbao are as famous for the quantity of their ores as for the quality of the metal produced from them; its coal fields are extensive and have the advantage of lying near the sea-coast; and ores of zinc and other metals abound. The exhibits made at Paris, however, as far as Class 43 isc oncerned, were utterly unsatisfactory, some of the most famous mines not even being represented by specimens of ore, and information either as to the mining statistics of the country or as to the nature and workings of particular deposits was conspicuous only by its absence.

coal and zinc.

Inadequate exhibit in Paris.

Under these circumstances the Commissioners would be justified in omitting any report upon the Spanish exhibit, but Spain plays a part really so important, and potentially so much more so, in the mining industries of Europe, that a few facts gleaned from various authors are here set down.

Report of Denis de Lagarde.

The following *résumé* of the product of the metallic mines of Spain is taken from a work by M. Denis de Lagarde:

Production of ores in Spain: 1867–1869.

Production of ores in Spain.

Ores.	1867.	1868.	1869.
	Tonnes.	*Tonnes.*	*Tonnes.*
Lead	337, 093	317, 670	278, 374
Argentiferous lead	30, 417	28, 908	33, 440
Silver	1, 648	3, 464	2, 931
Argentiferous pyrites	25	500	1, 825
Copper	237, 488	227, 732	306, 620
Argentiferous copper	116	95	223
Zinc	86, 822	131, 407	113, 485
Nickel and cobalt	122	1	83

While no trustworthy figures are attainable for the product of the Spanish mines since 1869, it is known that the figures of the above table have undergone considerable modification. The amount of lead and zinc produced has diminished, while that of copper has largely increased.

The lead mines of Murcia.

The chief lead-mining province of Spain is Murcia, on the southeastern coast, which produces two-thirds of the yearly output. The province of Santander, on the Bay of Biscay,

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Zinc mines of Santander and Murcia.

in Old Castile, leads in the production of zinc, but the province of Murcia stands next to it, and the two together produce nine-tenths of the total zinc product of the country.

Copper.

Almost all the copper is produced in Huelva, which lies in the southwestern corner of Spain, adjoining the great pyrites-mining district of Portugal.

Iron ore.

Iron ore is largely mined both in the Bay of Biscay, in the neighborhood of Bilbao, and in the southeast (Murcia),

Coal.

while coal comes chiefly from Asturias and Palencia, on the northern coast, but also from Cordova, in the south.

The following notes are mostly taken from M. J. Pechar's valuable treatise, *Kohle und Eisen in allen Laendern der Erde:*

Cause of the inadequate prosecution of coal mining.

Spain possesses such important deposits of coal that the entirely inadequate prosecution of coal mining would be very remarkable were it not fully explained by the unfavorable political conditions of the country.

Extent of Spanish coal fields.

The extent of the coal fields of Spain is estimated at 906,720 hectares (nearly 3,500 square miles). The store of coal is supposed to be from 3,000 to 3,500 million of tons. Of this two-thirds can certainly be mined with profit, and at the present rate of consumption (a million and a half of tons a year) would last Spain for 1,300 years.

History of coal mining in Spain.

Coal mining in Spain was begun about the middle of the eighteenth century, but in 1825, on the promulgation of a new mining law, there was no coal being mined. Since that time there has been a very gradual rise in the production and consumption. But more than half the amount used is still imported, as will be seen by the following table:

Statistics of Spanish coal mines and workings.

Provinces.	Extent of coal properties being worked.	Number of workmen employed.	Steam-engines.		Product.
			Number.	Horse-power.	
TRUE COAL. (Coal.)	*Acres.*				*Tonnes.*
Oviedo	51,874	3,883	6	144	374,914
Cordova	1,769	1,066	14	272	176,336
Palencia	3,341	1,540	8	97	119,259
Sevilla	94	120	3	95	13,500
Gerona	748	42	1	50	6,380
Leon	995	39	......	......	4,721
Burgos	408	48	......	......	230
Total	59,229	6,738	32	658	695,340
LIGNITE. (Lignite.)					
Barcelona	4,605	165	1	10	7,516
Santander	198	66	......	......	2,022
Guipuzcoa	304	12	......	......	1,584
Teruel	1,047	77	......	......	1,157
Logroño	124	10	......	......	243
Alicante	119	12	......	......	208
Balearic Isles	282	51	......	......	200

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Statistics of coal industry.

Provinces.	Extent of coal properties being worked.	Number of workmen employed.	Steam-engines.		Product.
			Number.	Horse-power.	
LIGNITE.	*Acres.*				*Tonnes.*
Navarra	30	4	......	......	200
Gerona	277	34	......	......	140
Oviedo	259	29	......	......	56
Castellon	272	27	......	......	20
Total	7, 517	587	1	10	13, 346
Aggregate	66, 746	7, 325	33	~~650~~ 668	708, 686

Production, importation, consumption: 1860–1877.

Years.	Production.			Importation.	Consumption.
	True coal.	Lignite.	Total.		
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1860	320, 899	18, 952	339, 857	452, 479	792, 330
1865	461, 396	34, 359	495, 755	394, 806	890, 561
1870	621, 832	40, 095	661, 927	566, 911	1, 228, 838
1871	589, 707	43, 824	633, 531	534, 897	1, 168, 428
1872	687, 791	33, 460	721, 251	592, 567	1, 313, 818
1873	658, 744	20, 938	679, 682	619, 248	1, 298, 930
1874	695, 340	13, 346	708, 686	580, 708	1, 289, 394
1875	628, 810	25, 689	654, 499	704, 287	1, 358, 786
1876	675, 926	30, 888	706, 814	774, 770	1, 481, 584
1877	699, 500	......	......	837, 053	1, 536, 553

Comparative consumption for various purposes.

In the report on England an interesting table was given showing the purposes for which the coal raised was consumed. The consumption in Spain from 1872 to 1874 for various purposes was as follows:

	Tonnes.	Per cent.
Mineral industries	500, 000	38. 6
Railways	190, 000	14. 7
Illuminating gas	110, 000	8. 5
Navy	28, 000	2. 2
Merchant marine	110, 000	8. 5
Various industries in Catalonia	146, 000	11. 3
Various industries in other provinces	216, 000	16. 2
Total	1, 300, 000	100. 0

Convenient position of the coal fields.

It is by no means impossible that the coal fields of Spain may hereafter be developed to an enormous extent. What gives them an especial value is that many of them lie close to the coast—an advantage shared in Europe only by the coal mines in Wales and the north of England. Spain is therefore in a position to supply with coal the countries lying about the Mediterranean, most of which are poorly off for mineral fuel, and to ship it through the Suez Canal to Asia. The first object must, however, be to supply the home consumption, for which purpose the output will have to be more than doubled.

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Coal.

What are the difficulties which have hitherto stood in the way of and still prevent the development of the coal fields? They are lack of capital, and of enterprise, and of facilities for transportation. When the legislation of Spain permits the association of capital; when, in general, the domestic conditions of the country have improved; when a system of railways has been developed; and when the managers of the railroads better understand the purposes for which carrying companies are founded, then no doubt mining in Spain will flourish in proportion to its mineral resources.

Consideration of the hindrances to efficient exploitation.

Iron ores.

The great wealth of Spain in the best of iron ores is well known. The Spanish deposits of the finest carbonate and oxide ores are among the most important in Europe. Under other domestic conditions Spain, possessing extensive coal fields, might compete with England in the iron industry. Up to the year 1873 the output of iron ores made great progress; in 1874, partly in consequence of the Carlist war, the production sank to one-half. No doubt the panic of 1873 in the commercial circles of all countries was also influential in the same direction.

The rich and important beds of iron ores.

Fluctuations in the output.

Political disturbances.

The following are a few data as to the production and exportation of iron ore, which cannot be extended for want of data. The unit is the metrical tonne of 1,000 kilos, or 2,205 lbs.:

Production and exportation of iron ores:

1871–1877.

Years.	Production.	Exportation.
1871	585,762	391,436
1872	781,468	745,802
1873	811,926	800,381
1874	402,952	....
1875	496,528	....
1876	908,899	....
1877	1,162,170	....

In 1877 the production of iron ore was distributed as follows:

Production by provinces.

	Tonnes.
Biscaya	702,090
Murcia	200,000
Oviedo	59,400
Other provinces	200,680
Total	1,162,170

Analyses.

The following analyses of Biscayan iron ore were made in the laboratory of El Carmen Iron Works, at Baracaldo, near Bilbao. Under the term *vena dulce* is understood the purest red hematite; *campanil* is also red hematite, which

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Iron ores.

for the most part contains limestone, and is especially sought for export, *mineral rubio* is brown iron ore:

Analyses.

	Vena dulce.		Campanil.			Mineral rubio.	
	1.	2.	1.	2.	3.	1.	2.
Iron oxide	86.26	80.78	80.75	84.01	73.90	79.14	83.75
Silica	1.35	2.63	3.24	3.20	5.70	7.20	5.25
Alumina	1.53	1.38	3.10	0.40	3.80	2.40	3.20
Manganic oxide	1.78	2.24	8.15	4.38	5.80	2.45	3.17
Lime	9.27	6.39	0.82	0.40	0.45	2.23	1.36
Magnesia	Trace.	0.46	1.04	0.80	1.25	0.71	Trace.
Sulphur	......	......	......	......	......	Trace.	0.04
Phosphorus	......	......	......	......	......	......	......
Water, etc	3.81	6.12	2.90	6.81	1.25	5.27	3.23
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Metallic iron	......	......	56.52	58.80	51.73	55.40	58.62

XII.

PORTUGAL.

PORTUGAL.

The following information is derived from articles published in the special catalogue of the exhibit of Portugal.

Geological character of the country.

Almost all the known geological formations are found in Portugal. One-third of its area is composed of igneous rocks, such as granites, diorites, porphyries, and basalts; a second third of the more ancient sedimentary formations, schists, grauwackes, and crystalline limestones.

Granites predominate at the north of the country and toward the center, syenites and diorites are more frequent to the south of the Tagus, and the porphyritic rocks are found almost exclusively at the center of Alemtéjo, in the southern portion of the kingdom, while the basalts occur to the north of Lisbon. The schistose rocks of the Archæan, Silurian, and Devonian formations occupy the remainder of the north and of the center, as well as of nearly the whole of the southern portion of the country. The Secondary beds constitute nearly the whole of the zone comprised between Aveiro and Lisbon, the mountains of Arrabida, and the shores of Algarve, the southernmost province of Portugal. Finally, the Tertiary and alluvial deposits cover a large area towards the center, and are found disseminated throughout the country. A great number of metalliferous veins, generally forming distinct groups, traverse these formations.

Ancient working of metalliferous deposits.

Many of the important ore deposits of Portugal were worked by the ancients, who left numerous traces of their operations. Mining, however, was for a long time utterly neglected, and may be said to have recommenced in our own days. Until 1820 the mines were considered as national property, and the ownership was vested exclusively in the government, but at the initiation of the constitutional system this monopoly was abolished, and private individuals were permitted to work the mines upon payment of an annual tax of five per cent. upon the product. This state of things continued until the close of 1852, when the law now in force was enacted.

Abolition of government monopoly in mines.

The mining laws.

The fundamental principle of this law is that mines are state property. Under it the discoverer of a metalliferous deposit or one of mineral fuel can record and enter on possession of a claim in spite of any opposition on the part

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of the proprietor of the surface; the latter is, however, entitled to full damages and to a royalty. It is obligatory upon the claimant, within six months after his claim has been inspected by a government official and pronounced legitimate, to begin active operations, otherwise the title is forfeited. A patent is granted in perpetuity, but the property must remain undivided, and must be continuously worked. Furthermore, the workings must be kept in a safe condition, and a tax of five per cent. on the net revenue is collected. Half of this tax is paid to the proprietor of the soil as royalty. A further tax is levied, amounting to $89 per 10,000 square fathoms.* The taxes collected form a special fund, to be applied in such ways as the government sees fit to the advantage of the mining industry. These taxes are not collected for two years after the patent is granted. Ores are subject to no export duties.

Mining laws. Respective rights of discoverers of metalliferous deposits, and of the proprietors of the land. Patents. Obligations of the miner claimant. Taxes.

On the 1st January, 1878, there were 276 concessions for mining enterprises in force.

Concessions in force in 1878.

The kingdom is divided into four mineral districts, and a mining engineer is attached to each in the quality of inspector. It is his duty to see that the provisions of the mining law are enforced.

Mineral districts.

Iron.—All provinces of the kingdom abound in iron ores, and each of the various ores of this metal is found in workable quantities. They are found in veins in the schists of Alemtéjo and among the Secondary rocks to the south of Leiria, where they are accompanied by beds of lignites.

Iron.

Lead.—Lead mines also abound, although many of them, supposed to be susceptible of great development, produce, as yet, but little ore. The most important seem to be the mines of Mertola, near the Guadiana. These contain galena yielding seventy per cent. of lead and from five hundred to six hundred grams of silver per ton. The carbonates which accompany the galena are sometimes still more argentiferous. Lead sulphate, crystallized and amorphous, also accompanies the ores. Sometimes tetrahedrite accompanies lead ores, which then carry from 950 to 1,000 grams in silver per ton.

Lead. Argentiferous galena, etc.

Copper.—The principal copper mines are in the Evora district, where a considerable number of veins are found in granites and porphyries. Another important deposit is that of Palhal, in Aveiro.

Copper.

The great metalliferous district of the Spanish province

* The Portuguese fathom is 86.56 inches English, and the above area is nearly 12 acres.

PORTUGAL.

Copper.

of Huelva also extends into Portugal, and great bodies of cupreous pyrites are found in Saint Domingos, Aljustral, and Grandola.

Tin.

Tin.—Tin is found in the granites near Porto and elsewhere, and as fluvial deposits in a large number of localities, but in small quantities.

Zinc.

Zinc.—Zinc is represented in Portugal chiefly by blende, found in association with galena. Blendes occur which are so argentiferous as to be classed with silver ores.

Portugal possesses also mines of manganese, antimony, nickel, cobalt, and silver.

Anthracite.

There are seams of anthracite near the Devonian schists of the mountains of Vallengo and of Bussaco, as well as a certain amount of Carboniferous territory to the southeast of Alcacer do Sal. There are also Jurassic lignites to the south of Leira and in the mountains of Buarcos. The coal mines, however, are not worked steadily, as they are scarcely profitable, though the coal is of good quality.

Lignite.

Salt.

Production.

Salt.—There are no less than 1,200 salt marshes on the coast of Portugal, and their product is estimated at 22,000,000 hectoliters. In 1866 246,000 tonnes, worth 1,400,000 fr., were exported.

Quarries.

There are over 800 quarries in Portugal, yielding marble, granites, slates, clays, sand, etc.

The mining industry of Portugal, while it is not unimportant, is subject to great fluctuations.

The following is the mean annual production of the Portuguese mines for the periods named:

Mean annual production of metals and coal: 1851-1872.

Ores.	1851-1860.		1861-1870.		1871-1872.	
	Tonnes.	Value in francs.	Tonnes.	Value in francs.	Tonnes.	Value in francs.
Cupreous pyrites	8, 956	300, 000	235, 840	7,005, 000	146, 894	4, 333, 000
Copper	1, 235	309, 000	4, 227	1,022, 000	1, 892	450, 000
Lead	950	211, 000	2, 931	638, 000	2, 213	488, 000
Antimony	60	17, 000	164	50, 000	19	5, 500
Tin	12	17, 000	7	17, 000	....	....
Coal	15, 462	372, 000	19, 002	578, 000	12, 387	305, 000
Manganese	....	....	8, 832	611, 000	14, 226	1, 226, 000
Argentiferous zinc	....	....	16	2, 000	....	....
Nickel	....	....	5	2, 000	....	....
Silver	....	....	1.2	500	....	....
Iron pyrites	4	....	23	500	....	....
Iron	....	....	1, 340	17, 000	2, 423	26, 000
Total	26, 679	1,226, 000	272, 388.2	9,942, 000	180, 054	6, 833, 500

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Table showing the exportation of Portuguese ores.

Exportation of ores:

1866–1876.

Years.	Lead.		Copper.		Tin.	
	Tonnes.	Value in francs.	Tonnes.	Value in francs.	Tonnes.	Value in francs.
1866	....	....	915	6, 969, 844	....	....
1867	239	72, 472	111, 873	5, 471, 233	....	....
1868	951	136, 972	85, 693	4, 398, 383	....	....
1869	2, 516	383, 022	140, 739	7, 011, 494	....	....
1870	1, 039	237, 938	274, 363	9, 178, 966	10	14, 861
1871	2, 328	316, 788	117, 667	5, 673, 705	129	30, 477
1872	1, 593	249, 466	181, 690	9, 077, 688	91	43, 861
1873	1, 408	260, 305	222, 025	11, 027, 777	57	91, 372
1874	1, 127	308, 316	168, 054	8, 275, 722	28	26, 005
1875	863	278, 550	167, 776	8, 809, 155	33	16, 494
1876	1, 289	456, 744	61, 773	3, 115, 200	58	21, 577

Exportation of phosphate of lime:

1866–1876.

Years.	Iron and manganese.		Phosphate of lime.	
	Tonnes.	Value in francs.	Tonnes.	Value in francs.
1866	619	59, 533	7	36, 427
1867	1, 809	103, 616	48	4, 083
1868	5, 223	498, 500	469	23, 161
1869	12, 994	442, 661	72	12, 500
1870	14, 428	650, 872	408	17, 027
1871	4, 442	217, 616	....	....
1872	21, 444	1, 424, 388	1, 817	97, 344
1873	30, 945	1, 303, 316	154	8, 555
1874	35, 009	1, 216, 450	357	11, 300
1875	43, 822	787, 572	4, 479	164, 355
1876	21, 569	559, 505	2, 902	76, 550

Consumption of metals:

The consumption of metals in Portugal was as follows in the years named:

1873–1875.

Metals.	1873.	1874.	1875.
Steel .... tonnes..	938	1, 020	1, 100
Antimony .... do ..	11	1	5
Quicksilver .... do ...	16	23	21
Lead .... do....	362	393	324
Copper .... do....	240	274	157
Tin .... do....	76	94	63
Iron .... do ..	24, 933	22, 634	28, 333
Tin-plate .... do ...	1, 139	1, 143	1, 267
Brass .... do....	324	234	227
Zinc .... do....	165	145	236
Gold .... grams..	73, 597	88, 700	39, 500
Platinum .... do....	4, 789	2, 280	101, 115
Silver .... do....	223, 877	94, 760	172, 430

Exportation of metals:

The following table gives the exportation of crude and manufactured metals from Portugal:

1873–1875.

Metals.	1873.	1874.	1875.
Steel .... tonnes..	92	135	114
Lead .... do....	54	29	149
Copper .... do....	51	194	272
Tin .... do....	1	....	13
Iron .... do ..	1, 665	1, 210	1, 713
Tin-plate .... do....	3	....	11
Brass .... do ...	96	96	35
Quicksilver .... do...	....	4	....
Zinc .... do ...	....	2	....
Gold .... grams..	145, 910	22, 252	23, 848
Silver .... do....	2,552, 808	2,624, 509	498, 096

PORTUGAL.

Pyrites mine of Saint Domingos.

The direction of the mine of Saint Domingos presented at the Exposition a pamphlet containing a very graphic account of the difficulties encountered and of the work accomplished at that important mining locality. As is well known, the enormously developed pyrites industry of Great Britain largely depends upon material from this mine. Besides the interest which the description derives from these facts, it will be refreshing to some readers to turn from the statistics which enter so largely into the present series of papers to an account of the industrial and social conditions under which mining enterprises are carried on in Europe, so curiously different as they are from those prevailing in the United States. Almost the whole of the *Notice sur la mine de pyrite* ~~*curioseuse*~~ cuivreuse *de S. Domingos* is therefore here translated.

Mine of Saint Domingos.

Geographical position of the mine.

In the midst of an arid and rocky country, at a distance of about nine miles from the Guadiana River and of nearly thirty miles from the sea, is situated the cupreous pyrites mine of Saint Domingos, in Portugal. It lies in the *concelho* or commune of Mertola (Mytilis Julia of the Romans), belonging to the administrative district of Lower Alemtéjo, the chief town of which is ~~Breja~~. Beja.

Geological description.

Geological sketch.—The geognostic character of this part of the country is almost identical with that of the metalliferous district of the province of Huelva, in Spain. Here, as in the neighborhood of the deposits of pyrites of Tharsis and Rio-Tinto, as at Aljustrel, and at Grandola, which form a sort of prolongation of the same zone towards the west, the metamorphism of the schistose rocks is very pronounced. For a long time this part of the country was classified as belonging to the Devonian period, and the rocks about the mine were considered as completely Azoic. The investigations which M. Nery Delgardo, a Portuguese geologist of the highest merit, has recently made, lead to the conclusion that the zone just spoken of belongs to the Silurian epoch, and shows perfectly distinct traces of organic fossils. In a very interesting paper which M. Delgardo presented to the Royal Society at Lisbon, he set forth the reasons which have led him to consider these rocks as a formation by themselves, having no connection with the other geological regions of the peninsula. From examination of the casts of fossils which he has found in the course of his researches, and of the geological phenomena the traces of which he has studied and compared in detail, M. Nery Delgardo draws inductions equally ingenious and plausible, which enable us

Nery Delgardo.

Deductions from the paleontological examination of the formation.

to follow step by step in their geological succession the vicissitudes which this part of the terrestrial crust has undergone at the remotest period of the earth's history.

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Mine of Saint Domingos.

The succinct nature of a notice like the present scarcely permits of our drawing more largely, as we should be truly pleased to do, upon geological and paleontological dissertations which form the matter of M. Nery Delgardo's memoirs.

Its geological character.

Overlying the sahlbands which limit the mass of pyrites, as well as in the barren country rock which formerly covered it, are found, among argillaceous schists, the croppings of which predominate everywhere, silicates, grauwackes, and numerous quartzose veins, which the metamorphism of the subsoil has given rise to among micaceous or talcose schists, the whole being covered with detritus. From the decomposition of these rocks there has been formed a clay impregnated with hydrated oxide of iron of a reddish color and a variable hardness, which envelops the pyritous ore body of Saint Domingos.

Mineralogical character.

Mineralogical character.—This mine, although inclosed in schists, does not take the form of a vein or exhibit a banded structure; it may be classed rather as a bedded mass, the axis of which is nearly horizontal. Its outline might be called navicular, or boat-shaped, for it is six hundred meters in length and sixty meters wide, and thins out in all directions.

The strike of the deposit is very nearly W. N. W. and E. S. E. In its general character it offers many points of resemblance to the pyritous masses of the same kind in Germany and Upper Italy.

Analysis.

The ore is a cupreous pyrites of iron. It contains, by dry assay, an average of 2.75 per cent. of copper and 45 to 50 per cent. of sulphur, accompanied by sulphides of iron and the other compounds which are generally found in the analysis of pyrites of a similar nature.

Archæology.

Archæology.—At the mine of Saint Domingos, as well as at the others in the same district, and at those of Tharsis and Rio-Tinto, in Spain, plain evidences of extensive operations by the Romans are met with, as well as vestiges—though somewhat indistinct—of still more ancient workings, which have been ascribed to the Phenicians or the Carthaginians. What has given rise to this supposition is, among other things, a marked difference in the degree to which the raw material has been exploited. This difference has been observed between the upper beds of the slag dumps left by the ancient miners about the mine and the underlying slags.

Evidences of Roman and still more ancient workings.

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Pyrites mine of Saint Domingos.

However this may be, the Roman workings, as is proved by the coins found in the course of the excavations, took place at the period between the latter portion of the reign of Augustus or the succession of Tiberius and the partition of the Roman Empire under Theodosius, a period of about three centuries and a half. The vestiges found of a settlement also date, in all probability, to this epoch, and are numerous and interesting. There have been found, in the center of the excavations, foundations and other remains of habitations, pedestals and fragments of columns, the latter, however, in small number and without artistic finish. There have also been found along the valley into which the drainage tunnel opens, rows of sarcophagi, covered with flags of the local schist, placed at small depth, and still containing bones, which fell to dust on coming into contact with the air. In later excavations have been found vestiges of the cremation of bodies, the ashes being inclosed in little urns; others, still smaller, are evidently what are called lachrymal urns. Besides these objects a great quantity of pottery has been exhumed, for the most part in fragments. It is greatly to be regretted that the awkwardness of the workmen employed in the excavations has prevented the recovery of these precious relics of the past in good condition.

Evidences of the Roman workings. Remains of habitations. Sarcophagi. Urns. Pottery.

Among the relics of mining operations the most remarkable are unquestionably the great wooden wheels which were found, like those in the mines of Tharsis, in a state of perfect preservation,* and which were used in pumping out water. These wheels, to the number of ten, are furnished with buckets upon their circumferences. Eight of them were 16 feet in diameter and two others were 12 feet.

Ancient norias.

Ancient adits.

The adits which the ancients drove to drain the mines have answered the purposes of the modern exploitation after having been suitably enlarged. The Roman workings reach a depth of 66 feet below this gallery in places. Being in search only of rich ores they left standing what seemed to them of low grade. As a consequence, their workings are very irregular, a fact which has caused the modern company great inconvenience and excessive cost in retimbering.

Present workings.

Present workings.—The mine is worked on levels, of which there are at present three. The first is opened at a depth of 40 feet, the second is 52 feet lower, and the third is 80 feet below the second. The upper two levels are now uncovered by the removal of the barren ground overlying the

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* As is well known, the absence of decay in the wood found in these mines is due to the presence of cupric sulphate, formed by the natural decomposition of the pyrites.—G. F. B.

deposit. The principal galleries are driven as nearly as possible parallel to the axis of the deposit and in contact with the north and south sahlbands. The other excavations particularly conform to the method of winning in "by cross-cutting," and extend from one drift to the other for nearly the whole distance. Two levels below those just mentioned are now being opened up. Formerly there were, besides, a number of shafts sunk from the surface vertically upon the ore deposit, which were employed for the extraction of the ore. The working of the mine having been undertaken as an open cast, as will presently be seen, these shafts successively disappeared by the removal of the ground through which they passed. There remain only those portions which were sunk in ore; these serve to ventilate the lower workings and maintain direct communication between the different levels.

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Pyrites mine of Saint Domingos.

The workings.

The principal excavations in the ore body are of the following dimensions:

Sizes of excavations.

Drifts, 6 ft. 6 in. × 6 ft. 6 in. to 24 ft. × 26 ft.

Cross-cuts, 6 ft. × 3 ft. 9 in. to 13 ft. × 20 ft.

The apparently excessive size of some of the drifts, especially in the upper levels, was unavoidable on account of the frequent occurrence of ancient excavations, which it was necessary to unite by arched passages of 23 ft. to 26 ft. in height, for safety in working.

The dimensions of the shafts below the timbering are ordinarily 7 ft. 4 in. × 3 ft. 8 in. in those portions which pass through solid overlying rock, and 6 ft. 7 in. × 8 ft. 3 in. in the ore.

The quantity of pyrites extracted from the mines from the first workings to the end of the year 1877 is shown by the following figures: Ancient excavations, estimated approximately at 150,000 cubic meters; modern excavations, 659,671 cubic meters; total, 809,671 cubic meters, or about 3,578,745 tons English.

Estimated quantity of pyrites extracted up to 1877.

Breaking ground in is performed under contract, on a system which has long been usual in the peninsula. The miners are paid so much per cubic meter, and the price includes the cost of tools, powder, dynamite, and other necessary materials, which are furnished the miners by the company at cost price. The manufacture and repair of tools is provided for on the spot, and the smiths are paid a fixed sum for making each implement. These mechanics are employed exclusively in working for the miners, and the labor is at their cost, while the fuel, the anvils, and all the forge-fittings are furnished by the company.

Contract system of breaking ground.

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Pyrites mine of Saint Domingos.

Removal of the whole overlying deposits.

In order to diminish the cost and facilitate the execution of winning in, to enable the complete extraction of the ore with a minimum of danger to the men, and above all to attain an increased rapidity in the workings and a larger output, the removal of the overlying material was undertaken in the year 1867. This barren ground had an average thickness of 32 meters. The project was put in execution as soon as conceived, with the approbation of the Portuguese Government, the liberality and good will of which, it should be said, has greatly facilitated the execution of enterprises on a large scale. This work is already considerably advanced, and has produced very perceptible results in diminishing the cost of the winning in of ore The greater portion of the deposit is now laid bare. The position of the ore body, which forms, so to speak, the core of a hill rising in nearly equal slopes from the surrounding valleys, has made the execution of the cuttings much easier. After the removal of the surface an excavation was first made in the center of the high ground. Tunnels were then run from the bottom of this excavation to the external slopes of the hill. These tunnels were run on a grade sloping outwards, and were made of sufficient size to accommodate locomotives and cars. Through them the remaining material forming the wall of the crater-like pit was removed. A system of such tunnels was established on each of the several levels upon which the removal of the barren rock was undertaken.

The ore body laid bare.

System of working.

Product up to 1877.

Cost.

The amount of material ~~received~~ stripped in this way up to the end of 1877 reaches the large figure of 2,488,824 cubic meters. The work has cost £225,000 sterling. The enormous mass of earth removed has nearly filled up the valleys surrounding the mine.

Extraction of the ore.

Mine locomotives.

Inclined planes.

Extraction of the ore.—The ore was formerly drawn out by mules, but this operation is now effected entirely by steam-power. For this purpose tunnels have been pierced from the mine to the slopes of the hill, with a downward grade toward the outer end. The upper tunnel, which serves to extract the ores from the open cuttings and the nearest underground workings, has a grade of only 5 per cent. Transportation was effected by locomotives of 30 horse-power. The timbering of this tunnel having been destroyed by fire, and the ground about it having been considerably disturbed, it was considered prudent to remove the overlying ground and convert it into an open roadway. In the removal of the pyrites obtained from the lower levels the ore has to surmount an incline of 30 per cent., and transportation is effected by buggies or cars drawn by a wire

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rope, which is attached to a fixed steam-engine of 90 effective horse-power, set at a distance of 180 meters from the mouth of the tunnel. This engine operates a drum of large diameter, about which the iron rope passes. Steel ropes have of late been substituted for iron. Another engine on the same plan is now being set up to answer the demands of the increasing output from the lower levels. A third engine is employed in pumping the water from the mines, the pump being single-acting and of large diameter. The pumping rods rest on cast-iron rollers fixed at the top of tall wooden trestles. In preparation for the time when all mineral capable of removal by tunnels and inclined planes shall have been extracted, two shafts of large diameter have been started. They are sunk at some distance to the south of the deposit, and are designed for hoisting from any depth by means of steam-engines.

Pyrites mine of Saint Domingos.

Stationary steam engines and wire ropes.

Pumping engine.

Shafts for lower levels.

Local treatment of the ore.—The problem of treating on the spot, with least possible cost, ores too poor to pay for exportation is a very difficult one to solve. This is so much the more the case as the usual plan for the treatment of pyrites includes roasting, which must naturally be carried out on a large scale. But preliminary trials on the ground aroused most energetic protests on the part of proprietors and farmers in the neighborhood, who complained of the damage done to the surrounding vegetation by the sulphurous fumes. Even the spontaneous and purely accidental kindling of certain piles of ore aroused seditious and menacing movements among the country people, and it consequently became necessary to abandon this method of treatment. Operations are hence, for the time being, limited to crushing the ores and saturating them with water from time to time. With patience and the lapse of years the copper will be extracted in a soluble condition and subsequently precipitated in tanks by cast-iron.

Local treatment of the ore.

Influence of the sulphurous fumes on neighboring vegetation.

Nature of present operations on poor ores.

Exportation.—The transportation of the pyrites from the mine to the port of shipment is performed by a railway of 3 ft. 6 in. gauge and locomotives averaging 55 horse-power. The distance is about 11 miles ($17\frac{1}{2}$ kilometers), but upon parts of the road the action is automatic, the grade being such that the cars descend without traction. At the bottom of the first down-grade the cars are attached to the locomotives and drawn up the ensuing up-grade, after which they descend as before. This method of transportation accomplishes a certain economy of fuel. the consumption of which is very great upon the steep up-grades.

Exportation.

Railway to the coast.

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Pyrites mine of Saint Domingos.

The construction of the railway from the mine to the shipping port on the Guadiana was accomplished in spite of serious difficulties arising from the broken and mountainous character of the country to be crossed. It was necessary either to leave slopes of 1 in 19 or to employ very powerful locomotives for the haulage of the ore, while in some places curves of 50 meters (164 ft.) radius had to be passed, rendering locomotives with a very short base essential. On the other hand, innumerable difficulties had to be overcome in conducting the traffic demanded by the exportation of the pyrites upon such a road, with freight carried amounting sometimes to 200,000 tons, or thereabout, per annum. If there be further taken into consideration the difficulties arising to the management through the excess of costs over profit, and the dearness of fuel, which has to be imported wholly from England, it will be readily seen that the transportation of the pyrites to the point of shipment is one of the largest elements in the price of our ores.

Difficulties incident to the transportation from the mines to the Guadiana.

Railway plant.

Twenty-four locomotives are in use at Saint Domingos; of these the more powerful are used on the railroad to Pomarão, and the others on the different roads within and without the mine for removing the barren material overlying the ore, etc. There are 791 cars, without counting the side-dump cars, exclusively used in terracing work. The rolling stock represents a total value of £83,342.

Ore exported.

The whole quantity of ore exported since the commencement of operations at the mine up to the end of 1877 amounts to 2,325,802 metrical tons. About 636,864 tons of low-grade ore have been set aside for metallurgical treatment on the spot.

Low-grade ores for local treatment.

Embarkation.

Embarkation.—If the construction of a railway across the country so broken as that through which the Guadiana runs was an enterprise beset with difficulties, the establishment of a shipping port for the large quantities of ore was scarcely less so. It was necessary to choose a part of the river at which a minimum distance from the mine should be combined with a sufficient depth of the channel to permit of access to steamers of deep draught. But just at the point where these advantages were combined the hills descended very steeply to the banks of the river. The creation of a port, the establishment of buildings, and the other necessary constructions here, *hoc opus, hic labor est!* Perseverance and the liberal use of capital, however, overcame the obstacles which the nature of the country offered to these plans.

Difficulty in establishing a shipping port.

The commencement was made by constructing a quay

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along which the ships were to anchor. The surface of the quay was raised to the level of the railroad from the mine. Rails were then laid to chutes in the quay, projecting to a point above the holds of the vessels to be loaded, and lined with boiler-plate. On reaching these chutes the cars are tipped on a rocker, dumping their contents directly into the vessel.

Pyrites mine of Saint Domingos.

The quay on the Guadiana.

The perfect success of this arrangement has led to the construction of a second quay at a short distance from the first. By these means 1,500 to 2,000 tons can be loaded per day if necessary without much difficulty. The problem of the embarkation of ores having been solved, the next step was to build a village for the accommodation of the necessary employés, and to construct warehouses, offices, etc. For this purpose it was necessary to make cuttings in the slopes, remove rocks, fill ravines, and open up roads where there had been mere trails, accessible only to the goats and herdsmen who till then had been the sole inhabitants of these regions. At last the port of Pomarão was established, a port now well known and annually frequented by more than 400 sailing ships and steamers of a capacity of from 250 to 1,500 tons. Two tugs are kept upon the river for towing the sailing ships from the bar of the Guadiana to the port of Pomarão, a distance of 30 English miles.

Capacity of loading arrangements.

The port of Pomarão.

There are at Pomarão a large number of warehouses, offices, dwellings, etc., for the various persons to whom the shipping of the ore gives employment or business. A portion of these buildings was destroyed by the terrible flood of the Guadiana which occurred from the 6th to the 8th of December, 1876. This flood, the most disastrous of which there is any record, produced the most terrible devastation, not only at Pomarão, but along the whole course of the river. Constructions of the most solid character, which had resisted all previous inundations, failed to stand this one, and the enormous volume of waters rushing down the mountains swept the country before it in its dizzy course, leaving nothing after its passage but a vast slough, which covered a scene of fearful destruction. It need scarcely be said that Pomarão was completely demolished and had to be reconstructed. Happily, these terrible phenomena are repeated only at long intervals.

The buildings and offices at the port.

The flood of December, 1876.

Destruction of Pomarão.

On the bank of the river opposite to the shipping port a steam apparatus has been placed to draw up cars charged with ballast, which is deposited at such a height as to be safe from freshets. Grave inconvenience would otherwise be occasioned by filling up of the channel. A steam-engine of 9 nominal horse-power draws the cars up the hill by a chain.

Arrangements for deposit of ballast.

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The mine of Saint Domingos, buildings, etc.—The village known under the name of Saint Domingos was built by the company which works the mine, in the immediate neighborhood of the works. For nearly twenty centuries, ever since it was abandoned by the ancient miners, this region has been a desert, occupied only by wild beasts and an occasional goat-herd with his flock.

Village of Saint Domingos.

Description of the company's buildings.

As soon as possession was taken the construction of a village was begun, which now entirely surrounds the hill of Saint Domingos. An enormous building was erected, which contains the lodgings of the director, the offices, the laboratory, the billiard-room, and a reading-room for the recreation of the employés. The latter contains a library and the greater part of the journals of Portugal and of the principal foreign countries. A church, dedicated to the Catholic worship, stood upon the highest point of the hill of Saint Domingos, and was in charge of a priest, whose salary was paid by the company. The enlargement of the open cast having encroached upon the site of this church, it became necessary to demolish it, after solemn deconsecration, leaving only the clock tower, which remains as a relic of the former edifice.

Church.

Religious service is now performed provisionally in a chapel which has been consecrated in another part of the company's estate, out of reach of the workings.

Hospital.

Among the buildings is a hospital, which has been established for the gratuitous treatment of the workmen, to which is attached a dispensary where medicines are furnished free of charge, the whole being under the care of a physician and an apothecary paid by the company. There are, moreover, a number of stores for the supply of food, etc., and 500 dwellings more or less spacious. Of course there are various foundries, carpenter and machine shops, smithies, etc. At Saint Domingos motive power is furnished in these shops by a 16 horse-power engine. There are also spacious storehouses for the supplies of the company. There are from 1,500 to 2,500 persons employed, according as the work is being more or less actively pushed.

Stores.

Dwellings.

Workmen employed.

For the purpose of making the works of Saint Domingos independent of the effects of the natural dryness of the country, and of supplying the needs of the constantly growing number of steam-engines, considerable capital has been invested in the construction of dams in the rivers and ravines in the surrounding country, which admit of storage of a sufficient quantity of water during the winter. The neglect of this precaution might be followed by serious con-

Storage reservoirs.

sequences, since the great heat of summer dries up all the water-courses in the neighborhood, and even the springs and wells. The largest of these reservoirs will contain from 5,000,000 to 6,000,000 cubic meters, and suffices for the supply of the boilers and of the various processes of saturation and cementation. There is even a project for the employment of the surplus water in the irrigation of lands about the mine. These lands have been acquired by the company with the intention of clearing them for the culture of such crops as are adapted to the climatic conditions of the place. The attempt has even been made to cultivate barley and oats, to serve as feed for the mules kept at the mine.

Saint Domingos mine.

Storage reservoirs.

As a hygienic measure, and for the purpose of modifying as far as possible the natural barrenness of the country, the culture of the *Eucalyptus globulus* (better known in America as the blue gum) has been undertaken in all suitable positions. This species is perfectly adapted to the climatic conditions and to the soil about the mine, and several thousand of the trees are already in a flourishing condition.

Culture of the *Eucalyptus globulus.*

The capital represented by the works, the railway, rolling stock, etc., of the mine and its dependencies may be estimated at £560,000. The general direction of the company is in London, and the ores are exported almost exclusively to England. A beginning has been made looking toward the manufacture of chemical products at Lisbon and elsewhere, but as yet only on a small scale.

Capital employed.

The managing director is Mr. James Mason, who has been successively made "Commander of the Order of Christ," "Baron of Pomarão," and "Viscount Mason of Saint Domingos" by the Portuguese Government, and has latterly been appointed "Commander of the Order of Charles the Third" by the Spanish Government. The commercial administration of the company in England, which is not less important than the able and energetic working of the mine in Portugal, devolves upon the brother-in-law of M. le Viscount de Saint Domingos, Mr. F. T. Barry, who has been elevated by the Portuguese Government to be "Commander of the Order of Christ," and promoted by a decree of November 22, 1876, to the title of "Baron de Barry."

James Mason, managing director.

F. T. Barry.

May this example excite the emulation of the Portuguese capitalists and lead them to the development of the abundant and varied resources which their country offers to their own benefit and that of the national industry. Domestic order, persevering work, and the intelligent application of capital will restore Portugal to the rank she formerly occupied among the powers of Europe.

XIII.

GREECE.

THE GREEK EXHIBIT.

The exhibits.

The exhibits illustrating the mineral industry of Greece possess a peculiar interest. The ancient mines of Attica, belonging to the most highly cultivated people of antiquity, were, unquestionably, worked with the utmost degree of technical skill the age afforded. While other ancient mines are obliterated by the weathering of the rocks or the pressure of the surrounding material, or have been worked by succeeding generations till every trace of their original character is gone, many of the mines in Attica bear every appearance of having been recently abandoned. The very tool-marks in the rock are so fresh that the form of the implements is apparent and nearly every detail of the exploitation can be followed. To a great extent we can also infer the methods of treatment of the extracted ore, from the relics hidden under piles of slag and mining waste. Few ancient writers touched upon such subjects, and if anything like technical treatises existed, which is improbable, they are lost.

Ancient mines of Attica.

Revival of ancient mining industry.

After having been abandoned for a couple of thousand years, the mineral industries of the country have been, as all know, revived, and Greece—an older mining country than Saxony or Transylvania—is a newer field for mining enterprise than Australia.

A. Cordella.

It is principally to M. A. Cordella that the public is indebted for a knowledge of the ancient and the modern mines of Greece, and from two of his publications, *La Grèce sur le Rapport Géologique et Minéralogique*, Paris, 1878, and *Le Laurium*, Marseilles, 1871, nearly all of the following information is drawn.

Geological condition of Greece.

The geology of Greece is in a very unsatisfactory condition from a technical as well as from a purely scientific standpoint. The lowest known beds of sedimentary origin are crystalline schists and saccharoid limestones. The age of these rocks is uncertain. Paleontological evidence there is next to none. M. Cordella found a single almost obliterated imprint, which seemed to him to belong to a Silurian crinoid animal. Dr. Neumayer found a Cretacean fossil (*Nerinaca*) near the foot of a tower, but was unable to find it afterwards

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in the same place. Cordella believes it to have occurred in a building stone from elsewhere. Mr. Sauvage also regards these rocks as Cretaceous, arguing from analogy. The technically important point involved is evident. If these crystalline rocks are truly Cretaceous, there is hope of discovering coal below them. If they are Silurian, the coal-bearing measures are probably wanting in Greece. These rocks constitute a very large proportion of the area of the country.

Geological condition of Greece.

The strata which have been identified by tolerably preserved fossils belong exclusively to Cretaceous and later eras, especially to the Tertiary, which is well represented.

Plutonic and volcanic rocks are also largely represented in Greece and possess some technical importance.

Gold.

Silver.

Gold is found in some fluvial sands of Greece, as a constituent of one bed of iron pyrites in the Morea, and accompanying silver in argentiferous lead, but the known occurrences of this metal are of no economical importance.

Occurrence of argentiferous lead, of zinc, and copper.

Ores of the other metals obtained in Greece, particularly of argentiferous lead, of zinc, and copper, occur for the most part in the crystalline and metamorphic rocks to which reference has been made, though the granite also contains veins carrying silver as well as of manganiferous iron ores and heavy spar.

Mines of Laurium.

Occurrence of the ores of lead, silver, and zinc.

The principal mineral district is that of Laurium, at the southern extremity of Attica. Here the ores of lead and silver, of zinc, and, to a smaller extent, of copper, occur sometimes as regular veins in the micaceous schists, and occasionally in irregular bodies in the limestone, but for the most part in segregations and beds at the contact between the limestone and the schists. These strata have been broken through by recent igneous rocks, to the influence of which the formation of the ore deposits is ascribed. The deposits are of great extent, as is proved by examination of the ancient workings and prospecting shafts. Thus, at Camaresa, the center of operations of the *Société des Mines du Laurium*, one of the beds has been shown to be metalliferous over an area of about 1½ square miles. The contact deposits are from 1 to 7 meters thick, and parallel ore-bearing beds are found at different levels. Of these the ancients recognized four, and the existence of other deposits below their deepest workings has been proved. It is plain that in the absence of labor-saving machinery the ancients cannot have cared to prospect below a certain depth. The ores consist of galena, blende, lead and zinc carbonates, copper sulphides, and carbonates. Pyrites, spathic iron ore, etc., are also constituents of the deposits. In general, the main

Extent of the deposits.

Ancient workings.

Nature of the ores.

portion of the ore bodies consists of galena, more or less mixed with blende, the zinc carbonate occurring on the walls and in part in separate deposits. A rare mineral, adamine, a zinc olivenite, has been found at Laurium, and seems characteristic of the zinc deposits there.

Mines of Laurium.

Ancient mode of working.

The mines of Laurium were worked by the ancients with great energy, thoroughness, and skill. The ore deposits were reached by vertical and inclined shafts. Tunnels were not employed, and, according to M. Cordella, with good reason, as the dryness of the mines made tunnels unnecessary for drainage, and the topography is unfavorable to their construction. The deposits were systematically worked, the veins by stoping from one level to another, the beds by pillars and stalls. When the ore was tractable it was all removed and pillars of dry masonry substituted. Where the galena was largely mixed with blende, which was of course intractable, pillars of vein matter were left. In thick beds two floors were established, as is now often done in thick coal seams. The extraction was very complete, even metalliferous wall-rock being removed.

Masonry pillars.

Dry masonry seems to have been exclusively employed in the comparatively few cases in which the roof or walls needed support.

Tools used.

The tools used in bringing down the ore and rock appear to have been picks, bars, and sledges. In hard rock picks with conical points were used, in softer material the point was pyramidal. Contrary to Reitmaier's supposition, fire does not appear to have been employed in bringing in the rock, which is not of an appropriate character for the application of that method. Traces of the use of tools are everywhere met with, and M. Cordella has found a gad which was once iron, and still retained its shape when found, though completely oxidized.

Slave labor in carrying ore.

Transportation was effected by slaves, who carried the ore up the inclined shafts, probably in skin sacks, as is still the practice in some eastern mines. Water must have been got rid of in the same way. The steps in the inclines up which the men went are still visible, as are the niches for earthenware lamps, some of which have been found in place. The use of the perpendicular shafts is not altogether clear. From the dumps surrounding them, M. Cordella is strongly of the opinion that both the windlass and pulley were known, and that they were used to some extent for hoisting. The shafts certainly served to promote ventilation, and at the top of some of them is found, offset from the main opening, a sort of chimney, in which a fire was

Ventilating shafts.

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probably built to increase the circulation of air. The shafts and inclines are nearly always rectangular and of about 4 square meters cross-section. The deepest shaft mentioned is 395 feet. None of the shafts penetrate to sea-level.

Mines of Laurium.

The ore as it was removed from the mine in ancient times was in part too poor for economical smelting, and was concentrated. Some of the concentrating apparatus, in a fair state of preservation, has been found under heaps of waste.

Ancient concentrating apparatus.

Although, as may be readily imagined, it is not possible to make out from the abandoned apparatus all the details of the process of ore-dressing as practiced by the Greeks, the main features can still be traced.

Water was scarce at Laurium and large reservoirs were built to store a supply. So solidly were they constructed that some of them might even now serve the purpose for which they were designed. The concentrating apparatus was ingeniously planned to permit the use of the same water over and over again. It consisted of a sluice some 70 feet long and provided with three sumps or wells at intervals in its length. The sluice was not straight, but made several angles in such a way that the lower end came close to the higher. Ore must have been placed at the higher end and washed with water taken by baling or otherwise from the lower end. A current was thus established, and the mixture of ore and gangue separated in virtue of the difference of specific gravity of the minerals.

Scarcity of water.

Ancient reservoirs.

Concentrating sluice.

The rich ore and the concentrations were smelted in shaft furnaces without preliminary roasting, a process for which they were very well suited, being nearly free from quartz and containing lime and iron. That the ore was not roasted is proved by the globules of fused galena found in the slags. Of the furnaces many have been found. They are of small height (our authority does not give this dimension), and about 3 feet in diameter. The fuel was wood or charcoal, and blast was supplied by bellows worked by hand. The results obtained were very fair, the slag containing from 5½ to 14 per cent. of lead. Many ancient slags found in Spain and Italy contain no less than 25 per cent. of lead.

Smelting furnace.

Fuel and blast.

Loss of lead in slag.

The furnace lead, which M. Cordella has reason to suppose averaged 0.4 per cent. of silver, or, say, $150 per ton, was refined by cupellation. The apparatus used has not been discovered, but the frequent occurrence of fused pieces of desilverized litharge proves the nature of the process.

Desilverization.

The silver was refined and the litharge reduced, and the resulting lead employed as material for weights, missiles, lamps, vases, pipes, etc.

Reduction of litharge.

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Mines of Laurium.

Assays: cupels.

The lead was assayed, and cupels of earthenware (M. Cordella merely says *de terre*) have been found in the dumps. They were of nearly the same form now in use, 1½ inches in diameter, ¾ inch high, and ⅜ inch deep.

Zinc accretions.

Zinc accretions formed at the tops of the ancient furnaces. They were sold for the manufacture of bronze, and, as it appears, also for use as medicine. If so, lead colic must have been familiar to the ancients, even at a distance from the mines.

Period of ancient activity 600–430 B. C.

State property.

Worked by slaves.

The period of greatest activity in the Laurium mines was between 600 B. C. and the Peloponnesian war, say 170 years. The mines were exclusively the property of the state, but they were leased to citizens in claims for long periods. The labor was performed by slaves, even the formen or superintendents being owned. M. Cordella estimates the number of workmen employed at Laurium at about 15,000. This was a vast body of slaves to handle, and must have required very strict organization. During the Peloponnesian war Laurium was cut off from the capital and the slaves revolted. It is very easy to see that the re-establishment of the workings on the only possible basis of slave labor must have been a matter of great difficulty in the troubled times which followed, and a knowledge of these circumstances sufficiently accounts for the historical fact that the mines were afterwards worked fitfully and with little energy, operations being sometimes confined to the resmelting of old slags, an enterprise which might evidently be conducted with small capital or permanent stake in the prosperity of the district. The mines were worked to some extent under the Romans, but through Greek factors. In the first century of the Christian era Laurium was completely abandoned and became once more the haunt of wild beasts. There is no evidence that work was ever recommenced until the present generation.

Revolt.

Subsequent workings on a small scale.

Abandoned 1st century of the Christian era.

Enormous extent of ancient workings.

Slag of former operations.

The amount of work done in the Laurium mines was enormous. Some 2,000 shafts have been found, averaging about 250 feet in depth, and the extent of the subterranean workings is vast. The quantity of slag found is about 2,000,000 tons, and M. Cordella shows that this slag must have represented 2,100,000 tons of lead and 8,400,000 kilos of silver, or, say, 345,000,000 of dollars. The whole period of 700 years during which operations were going on at Laurium M. Cordella regards as equivalent to about 300 years of active work.

Mining laws of 1861.

The modern development of the mineral industries of Greece dates from the promulgation of mining laws in 1861.

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These laws were founded upon those embraced in the French legislation of 1810 on the same subject. Since this time many persons have boldly undertaken mining enterprises, and the country has been prospected foot by foot. Many economically valuable deposits have been discovered. Some of them are being worked, others are waiting for the capital necessary to develop them. It was at this period that the *Société Hilarion, Roux and Co.* was formed. This company undertook in 1864 the resmelting of the plumbiferous slags of Laurium, and in 1869 the smelting of the ancient mining waste.

Société Hilarion, Roux & Co.

Resumption of work at Laurium.

Prodigious excitement followed upon the results obtained by this company. Claims were taken up by the hundred all over the kingdom on deposits of lead, zinc, copper, iron, manganese, chromium, lignite, and sulphur. Of course time proved the fallaciousness of many hopes and the necessity for patience and capital, and the inevitable process of weeding out has followed. A portion of the more hopeful enterprises have attracted the support of foreign capital.

Mining excitement.

The want of acquaintance on the part of the public in Greece with the conditions of industrial enterprises, and the lack till lately of Greeks possessing any professional acquaintance with mining or smelting, have been calamitous to the mineral industries of Greece. For a long time commissioners visited Laurium at short intervals to find the gold bars and the hidden sources of supply of the bullion turned out by the smelting works. That this was the legitimate result of the treatment of ores and slags was not credited. Then, by a sudden change in popular sentiment the contents of the material at Laurium was as much overvalued as it had previously been undervalued, and taxes were placed upon the working amounting to more than half the worth of the output. The Hilarion Company was obliged to sell out, their successors and many others were nearly or quite ruined, and affairs reached such a pass that the interference of foreign governments had to be called in for the protection of the rights of those of their subjects who had ventured to attempt the development of industry among a people whose tone of mind was so little congenial to it.

Ignorance of the Greek public,

and of Greek officials.

Ruin of the companies by unjust taxation.

Interference of foreign governments.

Of late years an essential change for the better has come about. Numbers of young Greeks have studied mining at the great schools of Europe, and returned to Greece. More equitable arrangements as to imposts have been made, and *La Société des Usines du Laurium* seems to be in a flourishing condition.

Change for the better.

GREECE.

Mines of Laurium.

Present works.

This company smelts ancient slag and mining waste and such lead ores as are now raised in the district. It possesses a mechanical ore-dressing establishment, where 300 tons of waste, containing 5 to 6 per cent. lead, are treated per diem, yielding 50 tons of concentrations. The remainder of the waste is concentrated at the ancient dumps in hand-jigs. The smelting works contain 7 Pilz furnaces.

Plant.

Product.

Plumbiferous iron ore is used as flux, and 12 per cent. of coke is burned. The annual product is 7,000 to 7,500 tons of lead, with $40 to $70 per ton in silver, and about 400 tons of speiss, containing 20 to 22 per cent. copper and 2 per cent. nickel, besides lead, arsenic, etc. The amount of fume caught in a condensation flue 1,200 meters long is from 1,200 to 1,500 tons.

French company of the Laurium mines.

Calamine, blende, and lead ores.

The mines of Laurium are also being worked with vigor by the *Compagnie Française des Mines du Laurium*, which began operations at the close of 1875. Calamine (carbonate), blende, and lead ores are raised. A portion of the calamine is roasted. The following are the results which have been obtained by this company,* in tons of 1,000 kilos:

Product.

	1876.	1877.	Half of 1878.
Raw calamine	1,166	2,425	3,006
Roasted calamine	4,810	18,477	10,104
Blende	....	340	119
Lead ores	....	432	507

The calamine of Laurium is richer than that of Sardinia, which is said to average about 33 per cent. The mean contents of the roasted calamine for each year was as follows:

Analysis of roasted calamine.

	Per cent. zinc.
1876	40.081
1877	51.30
1878, above	60

Zinc ore sent to Anvers and Swansea.

The last steamer-load was settled for on a basis of 65.585 per cent. zinc. There is a large amount of calamine in sight, and the boast seems justified that this is the most important output of calamine in the world. The zinc ore is sent to Anvers and Swansea.

Blende and galena separating works.

The lead ore raised is mostly mixed with blende, and the company has built an ore-dressing works to separate the two. The galena is very rich, much of it running over $90 to the ton of lead.

Other metalliferous deposits.

There are numerous other deposits of ores in Greece, not only of lead and zinc, but of copper, iron, and sulphur.

* *Note sur les Mines de la Com. Fran. des Mines du Laurium.* Lithographed.

Many of these have been prospected, and even worked. Thus, 45,000 tons of iron ore have been extracted at Serephos, and smelted in England with results highly satisfactory so far as the metal was concerned. In the eparchy of Phthiotide two copper mines of a very promising character have been opened, and in the island of Milo sulphur is actually being extracted to some extent, but the unwise policy of the Greek Government until a recent date, the general badness of the times, and the recent protracted wars on the Greek frontier have prevented active exploitation. Greece, however, promises much in the near future.

Iron ore.

Copper.

Sulphur.

No true coal is known to exist in Greece. The coal and coke annually imported from England amount to 76,000 tons. Lignite, however, occurs over large areas, estimated at some 1,200 square miles. This lignite is of very fair quality, and is easily mined. Its heating effect is much less than that of English coal, and it takes from 125 to 150 parts of the native product to do the work of 100 parts of the imported fuel. About 6,000 tons were mined in 1877.

No true coal in Greece.

Lignite.

The exhibits made by Greece were of a highly interesting character, and illustrative of the facts set forth in the foregoing pages. The ores, ancient slags, and mining waste found at Laurium were shown, and M. Cordella presented models of the simple and ingenious ore-dressing apparatus in use when Rome was struggling into notoriety. The story of Laurium is certainly one of the most romantic chapters in the history of technology. The genius of Athens may fairly be said to have mastered the difficulties presented, but the conquest was dependent on unnatural economical conditions, and was consequently temporary. The hold which modern science has taken on the subterranean treasures of Attica will not be so easily shaken off.

Character of the exhibit in Paris.

Models of ancient ore-dressing apparatus.

XIV.

NETHERLANDS.

THE DUTCH EAST INDIES.

THE DUTCH EXHIBIT.

Scarcity of minerals in Holland.

Holland produces no valuable minerals, unless a certain quantity of dredged peat may be so considered. The Dutch possessions in the East Indies, on the other hand, lie in a remarkable mineral belt, extending from the mainland through the peninsula of Malacca into the Malayan Archipelago. This region furnished the only important supply of tin, besides the mines of Cornwall and Devonshire, until the recent discoveries in Australia. Banca tin, too, is renowned for its great purity. Gold, gems, and coal also occur, and occasionally in remunerative quantities.

The rich mineral belt of the Dutch East Indies.

Banca tin.

The mineral resources of the Dutch Indies are not yet thoroughly investigated, and there seems a probability of considerable increase in their productiveness. It is only within a few years that the Billiton mines began to put tin upon the market in considerable quantities, causing a sudden depression in the price of that metal, a harbinger of the greater disturbance caused by the discovery of immense deposits in Australia. New tin fields have since been found, and bid fair to become important.

Billiton tin mines.

Exploitation by Chinese.

All work connected with the exploitation and treatment of tin ores is performed by Chinese. Formerly agents were appointed to encourage their emigration, but at present they present themselves in sufficient numbers. They work in companies, under contract, receiving a fixed price for tin delivered, and enjoying some privileges in the matter of supplies. European engineers exercise a certain amount of control and supervision.

Exhibit of R. H. Arntzenius.

The exhibit of M. R. H. Arntzenius, manager of the Billiton Company, and the collective exhibits of the products of the Dutch Indies, gave very full and interesting information as to the methods, instruments, and apparatus employed, as well as of the products obtained, the mode of life of the miners, etc.

Cornelius de Groot's account of the Netherlands mining industries in the East Indies.

M. Cornelius de Groot, who was formerly at the head of the Department of Mines in the Dutch East Indies, prepared, at the request of the members of the jury, a short account of the mining and metallurgical industries of Banca, Billiton, and the other islands belonging to the Netherlands. As

NETHERLANDS.

the subject has considerable commercial and professional interest, while but few papers on the subject have been published excepting in Dutch technical journals rarely seen in America, some space may well be devoted here to an abstract of the above-mentioned essay. Some supplementary information will be properly accredited.

The island of Banca.

Banca.

Geological description.

The sedimentary rocks are argillaceous and quartzose sandstones, etc., belonging to the Lower Devonian (Grauwacke). The crystalline rocks are, for the most part, granite, to some extent diorite, and rarely griesen and schists. The remaining formations are of Quaternary origin, and it is in these that the tin ore, "stream-tin," occurs. Veins containing tin ore occur in Banca, and the griesen is sometimes impregnated with tin-stone, but the mineral is for the most part found in reticulated veins (stockwerke), associated with quartz.

Occurrence of the stream-tin.

Occurrence of the tin-bearing gravels.

The tin-bearing gravels of the island are found in ancient or recent valleys, and deposited in one of three ways: disseminated through the surface stratum to the depth of nine feet or more; disseminated through several beds, one above the other. These beds consist, besides the stream-tin, of but little-worn fragments of quartz and feldspar, sand, etc. Finally, the tin-stone is found disseminated through quicksands which rest upon the bed-rock. The latter is sometimes granite, but oftener kaolin, or, in other words, granite in a highly advanced stage of decomposition.

Chinese prospecting apparatus.

In prospecting for tin-stone a small Chinese boring apparatus called Tsjam is employed. This apparatus* consists of an iron rod over 20 feet long and 1 inch thick, to the lower end of which is attached by its side a conical tube of a few inches in length, open at both ends, and with the smaller end down. In use, the small end of the tube is stopped up by a rag, attached to a string, while sinking through superficial strata. When the bed under examination is reached, the rag is detached by pulling the string, and the tube fills with gravel. To determine the value of an ore-bearing stratum, a copper tube armed with a steel cutting shoe is forced through it, and a core thus removed for examination.

Open workings.

The workings are all open, and not more than 8 or 9 meters in depth. After excavation the tin-stone is ~~worked~~ washed free of barren gravel.

The reduction of the ore is carried on in two different

* See *Berg- und Hüttenmännische Zeitung*, 1863, p. 338.

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Tin-reduction furnace.

species of furnace,* one of the Chinese design, which has been in use ever since the mines were worked by Chinese, the other the construction of Dr. C. L. Vlaanderen. The

Chinese furnace.

Chinese furnace consists of a kettle-shaped smelting chamber, cut in a clay hearth, and connected by an open tap with an external well, into which metal and slag run together as fast as they melt. The fuel is charcoal, and the blast nozzle entering the lower portion of the smelting chamber is directed downward upon the bottom of the chamber to keep it hot. The slag is resmelted once or twice, besides being crushed and washed. The blast is produced by piston blast engines worked by hand.

Vlaanderen's furnace.

Vlaanderen's furnace is a small open-top blast furnace, run with a fan blast. The height is somewhat over 5 feet, and the cross-section nearly square and 2 feet 3 inches from front to back. There are three tuyeres, which are so placed that the jets of blast cross each other. The fuel used is charcoal, and lime is added as a flux. The "glass" is thrown into water and subsequently re-smelted with more

Tungsten.

lime. Tungsten, which is however rare in Banca, is reduced in the comparatively hot Vlaanderen furnace. The furnaces are run only during the night on account of the heat, the island lying nearly under the equator. Several other constructions of furnace have been tried in Banca, but with indifferent success. Furnaces of a very simple construction like those above mentioned are preferable, because they can be set up in the immediate neighborhood of the workings, and removed or abandoned as the deposits

Bredemeyer.

are successively exhausted. Bredemeyer† speaks of roasting the tin ore in reverberatory furnaces, and leaching out copper, etc., but of this De Groot makes no mention.

Proportion of metal in the ore.

The ore carries from 71 to 72 per cent. of pure tin. A slab of tin weighs ½ picul, or 30.8806 kilos, according to De Groot. According to a printed description of the exhibit,

Weight of tin slabs.

the weight of a slab is about 32 kilos, and Mr. R. Hunt states that 1,000 slabs weigh 32 tons, in which case a slab must weigh 32½ kilos.

Government workings.

The government undertook the working of the tin deposits in 1816, employing Chinese miners and smelters, of whom the number at work at the end of the year 1876 in Banca was 7,789. The natives are known to have smelted tin fully two centuries ago, and continued to produce metal in small quantities until the Dutch Government took the matter in hand.

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* See, also, *Van Diest, in Berg- und Hüttenmännische Zeitung*, 1873, p. 423.

† *San Francisco Mining and Scientific Press*, 1872, p. 470.

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The production is known since the year 1821. In that year it was 1,250 metrical tons* of tin. In the year 1846 the production exceeded 4,400 tons, and attained its maximum, 6,250 tons, in the year 1856; since then it has diminished gradually to a mean of 4,340 tons in the years 1871 to 1875, while in 1876 Banca produced but 3,932 tons. Production of tin in 1821-1876.

Prof. G. J. Mulder analyzed Banca tin with the following results: Analysis of Banca tin.

Lead	0.014
Iron	0.019
Copper	0.006
Impurities	0.039
Tin	99.961
	100 00

Considerable deposits of magnetite are found in the eastern part of the island. Gold is found in small quantities with the stream-tin, and sometimes in quite important quanities on the sea-beach in the district of Merawang. Gold.

The island of Billiton. Billiton.

The geological formation and the methods of working the ore are essentially the same as those of Banca. Stockwerke take a more important place, and are mined to some extent. Tungsten occurs in a single mine, and in another galena is met with. Copper occurs only in traces. Geological formation.

The tin deposits in Billiton were discovered by M. De Groot, in 1851, and the workings were opened in 1853, in which year 11 tons of tin were produced (1 ton equals 1,000 kilos). In 1863 the production was 645 tons, and in 1870, 2,957 tons; for the years 1871-'75, both inclusive, annually 3,390 tons, and in 1876, 3,721 tons. C. De Groot. Discovery of tin deposits in 1851. Production 1851-1876.

Dr. Vlaanderen analyzed Billiton tin, which is of the same degree of purity as Banca tin. It contains, however, about .03 of 1 per cent. of arsenic and antimony, but no copper. Analysis of Billiton tin.

The Billiton tin mines are worked by a stock company, employing Chinese workmen.

Other tin deposits in the Dutch East Indies.

Cassiterite is found in small and not important but workable quantities in the little islands of Karimon and Singkep. A concession has been granted for working deposits of tinstone in Negri Tapong, a mountainous district in Eastern Cassiterite in other islands.

*A metrical ton is 1,000 kilos, or 2,205 lbs.

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Tin mines in Dutch East Indies.

Sumatra, and in 1877 200 Chinese miners were at work there in three mines. A company is being formed for working these deposits on a larger scale.

Coal.

Coal is mined in the eastern and southeastern portions of Borneo. It occurs in the Lower Eocene and appears to be of a fair quality.

Diamonds.

Diamonds are found in the eastern and in the western parts of Borneo, in the detritus, but thus far not in place. Itacolumite is found with them in the detritus. They are also found not far from mountains of serpentine. No report is made of the quantity or value of the diamonds found.

Gold.

Gold is found in many parts of the Dutch Indies; in paying quantities in the interior of Sumatra and Borneo, in the north of Celebes, and on the island of Kassarouta, in the Moluccas. Platinum is found associated with gold, and with it, in some instances, ruthenium sulphide.

The quantities of Banca and Billiton tin yearly put upon the market are regularly reported in the *Mineral Statistics of Great Britain.*

XV.

BULLION PRODUCT OF THE UNITED STATES.

Little that is new to mining men in this country could be said of the United States exhibit in Class 43. Instead of any attempt to do so, the following discussion of the bullion yield, perhaps the most condensed and exhaustive which has as yet appeared, is submitted as a valuable addition to the English literature of this important subject, and as being in harmony with the tone and purpose of the preceding essays.

"THE PRODUCTION OF THE PRECIOUS METALS IN THE UNITED STATES.

Bullion product of the United States, by Dr. Adolf Soetbeer.

BY DR. ADOLF SOETBEER.

[*Petermann's Mittheilungen, Ergänzungsheft No.* 57. Translated by A. T. Becker.]

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Berichte des deutschen (Resp. preussischen) Konsulats in San Francisco, Veroeffentlicht im preussischen Handels-Archiv, 1850–'74.

F. von Richthofen. Die Metall-Produktion Californiens und der angrenzenden Laender, Gotha, 1864, 4°.

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W. P. Blake. The Production of Precious Metals, etc., New York and London, 1869.

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Report of the Select Committee on Depreciation of Silver, Parl. Pap., London, 1876, fol., Appendix No. 8–19, No. 21, pp. 133–147.

E. Suess. Zukunft des Goldes, Wien, 1877, 9, 118–157.

Report and Accompanying Documents of the United States Monetary Commission, vol. i, Washington, 1877, Appendix, pp. 1–60.

A. Del Mar. Report on Silver Production in the United States.

Bullion product of the United States.

"Two essentially different periods may be distinguished in the production of precious metals in the extensive region of country which now comprises the United States of America. They are separated by the discovery of the gold fields of California. Before the year 1849 the United States yielded perhaps less gold and silver than any other diversified region of country of the same extent. Since then the country has rapidly advanced to the foremost rank in this respect. We first meet with traces of gold-mining at the end of the last century in Virginia and South Carolina. The industry became somewhat more important between 1820 and 1840, when gold was also found in North Carolina, Georgia, Tennessee, and Alabama, and the gold obtained was coined in the newly-established mints. According to the summaries of Mr. J. D. Whitney, the gold product in the separate States from 1804 to 1850, and in the respective divisions of time, was as follows:

J. D. Whitney.

Gold production previous to 1850.

Value of gold production from 1804 *to* 1850.

Virginia	$1,198,600
North Carolina	6,842,900
South Carolina	818,100
Georgia	6,048,900
Tennessee and Alabama	263,800
Total	15,172,300

Value of gold production in the respective divisions of time.

1804–'23	$47,000
1824–'30	715,000
1831–'40	6,695,000
1841–'50	7,715,000
	15,172,000

Gold delivered at the eastern mints, 1851–1867.

"From 1851 to 1867 the whole amount of gold delivered at the mints in the Eastern States amounted only to $4,391,915. How insignificant this sum appears when compared with the enormous quantities of gold California and, latterly, also other States and Territories west of the Rocky Mountains have produced since 1848. It is a difficult task to ascertain even approximately the quantity of gold which has been obtained here, and all the estimates which have been made must be regarded as untrustworthy, as they vary very much from one another. They have for the most part been founded upon the export returns of San Francisco, the coinages and assays in the mints, and, above all, the books of Wells, Fargo, & Co., who have transported much the greater part of the precious metals from the various mining districts lying west of the Rocky Mountains, and keep exact accounts of the

Means for estimating the production of the region west of the Rocky Mountains.

Bullion product of the United States.

same. Such estimates cannot however be regarded as accurate, for mere opinion based on probabilities enters largely into them. A considerable part of the gold obtained by thousands of isolated gold-diggers is exported either by the owners themselves or by their friends, and does not appear on the books of the express agents or in the export returns of San Francisco. The valuations in question usually include silver. This was especially the case in former times, when the silver product was comparatively small. In many of the estimates of later years, on the contrary, a part of the gold product is reckoned with that of the valuation of the silver, especially in the product of Nevada. Moreover, it must not be forgotten that in the sum total of the aforementioned estimates gold is included which was originally obtained in British Columbia or in the mining districts of Mexico adjacent to California, and which is, therefore, not to be reckoned as the product of the United States. It also sometimes occurs that in the summary of the amounts transported the same item is twice stated. Therefore, we must allow a wide margin for errors, nor should we lose sight of the fact that the temptation to overestimate would naturally be much greater than to underestimate.

Means for estimating the quantity of gold produced west of the Rocky Mountains.

Table of the export of gold and silver from San Francisco, 1848–1863, by Richthofen.

"We will begin by giving a table of the export of gold and silver from San Francisco from 1848 to 1863, taken from the commercial publications of that city, which are based on the custom-house schedules, and are given by Mr. Blake, and also by Herr von Richthofen in the above-mentioned treatise, *Die Metall-Produktion Californiens und der angrenzenden Laender*. An addition has been made to the amounts declared during the years 1848–'59, on account of the acknowledged incompleteness of the official returns. On the other hand, for the years 1861, 1862, and 1863 a reduction has been made of, respectively, one and a half millions, six millions, and thirteen millions, on account of the silver contained in the amounts declared. The export of the latter by way of San Francisco has become of greater importance since 1861.

Declared and estimated gold export from San Francisco: 1848–1855.

Years.	Declared gold export.	Estimated actual gold export.
1848	$66,000,000 (1848–1850)	$10,000,000
1849		40,000,000
1850		50,000,000
1851 up to May 1	11,497,000	55,000,000 (1851 up to May 1 and 1851)
1851	34,960,895	
1852	45,779,000	60,000,000
1853	54,965,000	65,000,000
1854	52,045,633	60,000,000
1855	45,161,731	55,000,000

Bullion product of the United States.

Gold exports from San Francisco: 1856-1863.

Years.	Declared gold export.	Estimated actual gold export.
1856	$50, 697, 434	$55, 000, 000
1857	48, 976, 692	55, 000, 000
1858	47, 548, 026	50, 000, 000
1859	47, 640, 462	50, 000, 000
1860	42, 325, 916	42, 325, 916
1861	40, 676, 758	39, 176, 758
1862	42, 561, 761	36, 061, 761
1863	46, 071, 920	33, 071, 920

Richthofen's remarks on the table.

"Richthofen elucidates his tables with the following remarks: "The gold product of California during the last few years may be estimated with considerable exactness, that produced in earlier years only approximately. The exportations three times a month per steamer via Panama, and by ship to China and other parts, serves as the basis for the statistical statements. These figures give almost the total export in gold coin and ingots during the later years, but do not include the gold remaining in the country. The amount of this latter is by no means insignificant, as in California paper money is not current and only payments in specie are accepted. Furthermore, the fact of silver being contained in the ingots of gold is not stated. But, as the average standard of gold is 0.850, this last-mentioned fact may be neglected as of small importance. Of far greater importance, however, is the fact that large sums are transmitted abroad through private individuals, and in former times even larger sums were thus exported in the form of gold-dust. In the first years the whole exportation was carried on in this way. In the preceding tables is given, first, the value of the gold according to official tables, and, secondly, the value according to estimates, in which the sums exported by private individuals are allowed for. Up to 1860 the recorded export consisted entirely in gold coin and ingots of gold. In order to obtain accurate estimates for the three years 1861, 1862, and 1863, the gold contained in the bars of exported silver must be taken into consideration, as it amounts to no inconsiderable sum. This fact has been left unnoticed in the above statement in order to present a clear idea of the yield of the gold mines and gold-washings." Herr von Richthofen further observes that the decrease in the California gold product is very noticeable when it is remembered that in former years the whole amount obtained was from the gold-washings of California alone, whereas in later years the gold mines of the whole country and the gold-washings of Idaho, Arizona, and British Columbia contributed to the sum.

Mode of making up the table.

Decrease in the California gold product.

"The decrease in the gold yield would have been even greater were it not for the increase of the Chinese population. A white man is rarely satisfied with $4 a day, whereas the Chinese work for $1, and even less, and consequently the abandoned gold-washings could be reworked with success.

Bullion product of the United States.

"Jacoby (*Archiv für wissenschaftliche Kunde von Russland*, B. 24) declares Herr von Richthofen's estimates to be too low; that the decrease in the export is no indication of a decrease in the product, and that the increase of the other products and exports of California is an evident cause for the retention of a much larger proportion of gold and silver in the country. It also appears unwarrantable to make no allowance for the gold which has been shipped during the past three years without declaration. The gold yield of California and the adjacent States for the years 1856–'62 may be estimated at an average of from seventy-five to eighty mllion dollars.

Jacoby's comments on Richthofen's estimates.

"Mr. W. P. Blake, who has extended the above tables of the export of gold and silver for the years 1874–'76 according to the custom-house schedules of San Francisco—viz, 1864, $56,707,201; 1865, $45,308,227; 1866, $44,364,393; 1867, $44,676,292—observes further: 'Without doubt large amounts of precious metal are carried away from San Francisco by passengers in the form of gold coin and ingots. The amount thus exported is variously estimated. Commissioner Browne estimates it at about two hundred millions up to the year 1865. This estimate is, however, probably too high. Usually an addition of 10 per cent. is made to the declared amount sent from the interior for what is carried off by the gold-diggers themselves, and which does not appear on the books of the express agents.' This addition must also be regarded as too great, for it would amount to more than the sums shipped without declaration. Blake estimates the whole precious-metal export of California as follows:

W. P. Blake's extension of Richthofen's tables.

Estimates of undeclared gold exported from San Francisco.

Declared export from San Francisco	$864,495,446
Undeclared export, assumed at 10 per cent. of the declared	86,449,544
Assumed to have been retained in the country	45,000,000
Total	995,944,990
Herefrom to be deducted as product of British Columbia and Mexico	35,000,000
Remains, in round numbers	961,000,000
Of this sum, according to approximate estimation, gold	807,000,000

Estimate of whole precious metal export of California.

"Before we proceed to the valuations of the entire bullion yield of the United States we will complete the above table

Bullion product of the United States.

Bullion export from San Francisco:

of the declared exports from San Francisco for the years 1868 to 1875 from published estimates by Mr. Valentine, superintendent of Wells, Fargo, & Co. Express. According to these statements the export amounted to—

1868–1875.

Valentine, of Wells, Fargo & Co.

1868	$35,444,395
1869	37,287,117
1870	32,983,140
1871	17,253,347
1872	29,330,436
1873	24,715,126
1874	30,180,632
1875	42,911,048

Bullion export: 1875–1877.

Estimate of the German consul.

"We add especial statistics of the bullion export from San Francisco during the three years 1875 to 1877 from the reports of the German consulate of that city, including the countries for which the exports are destined, as well as the nature of the same.

Export of bullion in ingots and gold-dust, in coin, and paper money.

[Paper money is included in the calculation merely in order that the sums of the two statements may agree.]

Destination.

Destination.	1875.	1876.	1877.
Export by sea to England	$173,147	$43,803	....
Export by sea to China	7,652,953	10,918,967	$17,601,274
Export by sea to Panama	2,070	10,300	5,292
Export by sea to Japan	6,963	981,854	643,049
Export by sea to other countries	507,321	440,610	874,574
	8,342,454	12,395,534	19,124,189
Remitted overland to New York	34,568,594	37,384,612	38,619,462
Total	42,911,048	49,780,146	57,743,651

This total export consisted in—

Nature of the exports.

	1875.	1876.	1877.
Gold ingots	$995,019	$3,457,323	$2,209,282
Silver ingots	8,734,714	10,733,367	8,820,082
Gold coin	24,939,587	21,761,040	29,600,525
Mexican dollars	1,822,978	2,897,113	2,671,666
Gold dust	44,972	28,246	22,397
Silver coin	1,140,919	5,168,931	5,763,297
Trade dollars	4,910,859	5,734,126	8,629,345
Peruvian dollars	....	....	27,057
Paper money	21,000	....	....
Total	42,911,048	49,780,146	57,743,651

U. S. Commissioner of Mining Statistics.

J. Ross Browne.

"Since the year 1867 a Commissioner of Mining Statistics, appointed by the United States Government, has held office. It is his duty to send in a yearly and circumstantial account to the Secretary of the Treasury. This report is then laid before Congress and printed. For the first two years this position was held by Mr. J. Ross Browne; after

Bullion product of the United States.

R. W. Raymond.

him by Mr. Rossiter W. Raymond, who in the year 1877 handed in his eighth annual report (for the year 1876). These reports, which, as the author states in the preface to the last, are concluded for the present, contain a vast number of details concerning the various mining enterprises and also much technical information of all sorts. Mr. Raymond has personally inspected most of the mines in the various States and Territories and put himself in communication with a large number of persons who could give him useful information on the subject in question, and from whom he almost invariably met with the readiest assistance. In collecting the statistical information he was especially aided by the express companies. On the other hand, the circulars containing lists of queries, which were distributed, proved of little use.

Value of Mr. Raymond's detailed statements.

Absence of comprehensive general estimates.

"Complete and statistically accurate accounts are given of many of the mining enterprises, but in regard to the summing up of the entire bullion yield one can readily perceive Mr. Raymond's diffidence about giving comprehensive statements as the result of his own special investigations, whereas it is precisely his estimates which have the greatest value for the public and the civil authorities. But this very reserve on the part of the author in giving general estimates, on account of the incompleteness of his materials, gives one confidence in his detailed statements. When Mr. Raymond occasionally, though with reservations, gives general estimates, they may be regarded as more authoritative than others, unless a decided reason for material deviation be given.

Annual yield of precious metals by States and Territories:

"The following tables contain the yearly reports of Mr. Raymond on the annual yield of the precious metals in the various States and Territories, and also a summary of the presumable total yearly yield of both gold and silver:

1868–1871.

States and Territories.	1868.	1869.	1870.	1871.
California	$22,000,000	$22,500,000	$25,000,000	$20,000,000
Nevada	14,000,000	14,000,000	16,000,000	22,500,000
Montana	15,000,000	9,000,000	9,100,000	8,050,000
Idaho	7,000,000	7,000,000	6,000,000	5,000,000
Oregon and Washington	4,000,000	3,000,000	3,000,000	2,500,000
Arizona	500,000	1,000,000	800,000	800,000
New Mexico	250,000	500,000	500,000	500,000
Colorado and Wyoming	3,250,000	4,000,000	3,775,000	4,763,000
Utah	......	.. ...	1,300,000	2,300,000
From other parts	1,000,000	500,000	525,000	250,000
Total	67,000,000	61,500,000	66,000,000	66,663,000

Bullion product of the United States.

Annual yield of precious metols by States and Territories: 1872–1875.

States and Territories.	1872.	1873.	1874.	1875.
California	$19,049,098	$18,025,722	$20,300,531	$17,753,151
Nevada	25,548,801	35,254,507	35,452,233	40,478,369
Montana	6,068,339	5,178,047	3,844,722	3,573,600
Idaho	2,695,870	2,500,000	1,880,004	1,750,000
Oregon and Washington	2,000,000	1,585,784	763,605	1,246,978
Arizona	625,000	500,000	487,000	750,000
New Mexico	500,000	500,000	500,000	325,000
Colorado and Wyoming	4,761,465	4,070,263	5,188,510	5,302,810
Utah	2,445,284	3,778,200	3,911,601	3,137,688
From other parts	250,000	250,000	100,000	500,000
Total	63,943,857	71,642,523	72,428,206	74,817,596

Total bullion product of the United States:

Total bullion product of the United States.

1848–1875.

Years.	Gold.	Silver.	Gold and silver.
1848	$10,000,000	$50,000	$10,050,000
1849	40,000,000	50,000	40,050,000
1850	50,000,000	50,000	50,050,000
1851	55,000,000	50,000	55,050,000
1852	60,000,000	50,000	60,050,000
1853	65,000,000	50,000	65,050,000
1854	60,000,000	50,000	60,050,000
1855	55,000,000	50,000	55,050,000
1856	55,000,000	50,000	55,050,000
1857	55,000,000	50,000	55,050,000
1858	50,000,000	50,000	50,050,000
1859	50,000,000	100,000	50,100,000
1860	46,000,000	150,000	46,150,000
1861	43,000,000	2,000,000	45,000,000
1862	39,200,000	4,500,000	43,700,000
1863	40,000,000	8,500,000	48,500,000
1864	46,100,000	11,000,000	57,100,000
1865	53,225,000	11,250,000	64,475,000
1866	53,500,000	10,000,000	63,500,000
1867	51,725,000	13,500,000	65,225,000
1868	48,000,000	12,000,000	60,000,000
1869	49,500,000	13,000,000	62,500,000
1870	50,000,000	16,000,000	66,000,000
1871	43,500,000	22,000,000	65,500,000
1872	36,000,000	25,750,000	61,750,000
1873	36,000,000	35,750,000	71,750,000
1874	....	....	72,428,206
1875	....	....	74,817,596

On the relative proportions of gold and silver in the sums total.

"That Mr. Raymond refrained from expressing an opinion in his latter reports in regard to the relative proportions of gold and silver in the sum total is explained by the fact that a sufficiently explicit statement had not yet been made of the gold contained in the ores of the Comstock Lode. On another occasion he estimated the silver product for 1874 at $32,800,000 and for 1875 at $41,400,000. In the material for the report of the British Parliamentary Commission Mr. Raymond's estimate in regard to the relative proportions of gold and silver in the total yield of the product for the years 1874 and 1875 is supplemented by roughly assuming the relative proportions of gold and silver in the total yield for the years 1874 and 1875 at the round sums of $40,000,000 gold and $32,000,000 silver.

"The following tables, made out by Mr. Valentine, of the presumable bullion yield in the United States from 1871 to 1876, have been published by Professor Suess: Bullion product of the United States.

Valentine's table of the bullion yield of the United States: 1871–1876.

Years.	Gold.	Silver.	Gold and silver.
1871	$35,900,000	$20,290,000	$56,190,000
1872	39,460,000	20,530,000	59,990,000
1873	40,460,000	28,250,000	68,710,000
1874	40,100,000	30,500,000	70,600,000
1875	41,750,000	34,040,000	75,790,000
1876	44,330,000	41,500,000	85,830,000

"Mr. Raymond's reports of the annual bullion yield in the various States and Territories west of the Rocky Mountains may be complemented by extracts from the report of the German consulate at San Francisco, according to approximate valuations of the amounts of gold and silver: Report of German consul at San Francisco. Value of gold and silver product: 1876–1877.

States and Territories.	1876.	1877.
California	$19,000,000	$18,174,716
Nevada	49,300,000	51,580,290
Oregon	1,200,000	1,191,997
Washington	100,000	92,226
Idaho	1,700,000	1,832,495
Montana	2,800,000	2,644,912
Utah	5,600,000	8,113,755
Arizona	1,400,000	2,388,622
New Mexico	500,000	379,010
Wyoming and Dakota	700,000	1,500,000
Colorado	7,000,000	7,913,549
Mexico	2,200,000	1,432,992
British Columbia	1,500,000	1,177,190
Total	93,000,000	$98,421,754
Subtracted for Mexico and British Columbia	2,700,000	2,610,182
Bullion yield of the United States	90,300,000	95,811,572

"Of this product, in 1877 ($98,421,754) about $50,000,000, or rather more than half the sum total, was gold, whereas of the yield in 1876 about $48,000,000 was gold and $45,000,000 silver. The consular report contains the following observations on the sources of these tables: 'The statements of the various mining companies regarding the yield of their mines are by no means accurate, for no one is disposed to 'show his hand,' and the artificially stimulated fluctuations of the stock market are dependent upon reports alternately hopeful and discouraging, and which have little in common with the real state of affairs. Wells, Fargo, & Co. still remain the most trustworthy authorities for the bullion yield, as the greater part of it is transported by them. In cases, too, where mere estimates only are possible, they have business connections through which they can arrive better than any one else at the correct valuation.' Relative quantities of gold and silver: 1876–1877. Difficulties in obtaining correct information from first parties. Data of the Express Company the most reliable.

Bullion product of the United States.

"The whole bullion product of the United States west of the Rocky Mountains is roughly estimated as follows:

Total bullion product of the United States, west of the Rocky Mountains.

California	$1,165,200,000
Nevada	396,600,000
Oregon and Washington	44,000,000
Idaho	65,000,000
Montana	130,600,000
Utah	35,500,000
Arizona	10,300,000
Colorado	52,600,000
Wyoming and Dakota	3,100,000
New Mexico	4,600,000
Total	1,907,500,000
From British Columbia	31,200,000
From the northwest coast of Mexico	7,400,000
Aggregate	1,946,100,000

Extracts from reports of the British consul at San Francisco.

"We extract from the reports of the British consul at San Francisco some of the observations which are annexed to the tabular statements, at the same time noting the fluctuations in the price of quicksilver, as they are of great importance in the milling of silver ores, not only in the United States but also in Mexico and South America.

Report for 1872.

"*Report for the year* 1872.—Wells, Fargo, & Co. Express forwarded silver to the value of $62,000,000, and as it may be presumed that at least a quarter more found its way to San Francisco through other channels, the statisticians do not consider $80,000,000 too high an estimate for the total bullion yield of the whole country west of the Rocky Mountains. The largest part of it, however, no longer comes from California, but from Nevada, which State is credited with $25,500,000. Comparatively the greatest advance was made by Utah Territory, whose share has been variously estimated at from $4,000,000 to $10,000,000, while the Washoe Silver Mines still remain the most productive. It is worthy of note that the gold product is on the decrease, while that of silver is on the increase. The quicksilver product in California amounted to 30,306 flasks; the price ranged from 85 to 87½ cents per pound.

Report for 1874.

"*Report for the year* 1874.*—The yield of the mines in the various States and Territories is larger than that of any preceding year, partly in consequence of the extraordinary richness of many veins, partly also because, the rains having been early and plentiful, mining could be carried on longer than usual. The returns exceed those of 1873 by

*No report has been presented for the year 1873.

$2,000,000, and those of 1872 by $12,000,000. The yield consisted of gold dust and ingots to the value of $26,358,776, of silver ingots (which, however, frequently contain one-quarter part gold) to the value of $35,681,411, and of argentiferous lead ores to the value $12,360,868. Utah yields principally argentiferous lead; the gold yield of this Territory in 1874 did not exceed $100,000. Colorado ingots contain about five-eighths silver and three-eighths gold. The mines of California (with the exception of the Inyo district) and New Mexico yield almost exclusively gold. The most important event was the discovery towards the end of the year of an ore body in the Comstock Lode which appears to surpass all former discoveries in size and richness. The yield of the quicksilver mines was 34,154 flasks; the price rose from $1.20 to $1.55.

Bullion product of the United States.

Reports of the British consul at San Francisco.

Report for 1874.

"*Report for the year* 1875.—The total yield for this year may be estimated at $90,000,000; for besides the $80,889,037 which were intrusted to Wells, Fargo, & Co. as the yield of the mines in the States and Territories lying west of the Missouri, ores, gold dust, etc., were exported by other and private means. The Nevada (Comstock Lode) mines yielded $5,000,000 more than in the preceding year, in spite of the fire, which caused a suspension of work for many months, and therefore the assumption that they will yield $50,000,000 in 1875 is not unfounded. The product of the California quicksilver mines was 53,706 flasks. At the end of the year the price had sunk to 62½ cents per pound.

Report for 1875.

"*Report for the year* 1876.—Wells, Fargo, & Co. transported $75,199,541 in gold and fine silver ingots. But a large amount of bullion from the distant mines was transmitted by private means and by post to save the high express and insurance rates, and the base bullion was sent almost without exception as freight. The sum total may be pretty accurately estimated at $93,000,000. In consequence of the loss which the mine owners met with through the depreciation of silver, they lowered the wages of the miners. The yield of the quicksilver mines in the year 1876 was unusually large, and amounted to 75,074 flasks. This increased produce reduced the price of quicksilver to 55 cents per pound.

Report for 1876.

"*Report for the year* 1877.—It was supposed that the gold yield for this dry year had been as poor as the wheat harvest, as water is almost as essential for mining as for agriculture. The primitive method of washing the gold found on the surface by hand (placer mining), now falling into disuse and undertaken to any large extent only by the

Report for 1877.

Bullion product of the United States.

Reports of the British consul at San Francisco.

Report for 1877.

Chinese, is as a matter of course dependent upon rain. So, too, is the process known as the hydraulic method, in which, hill-sides are disintegrated and strata of auriferous gravel are washed out. Jets of water issue from movable nozzles of 6 and 10 inches in diameter under tremendous pressure towards the bank which is to be demolished. This method of mining, too, must suffer from a dry year, although the water-power is obtained from large brooks which seldom run dry. Finally, in very many of the tunnel mines proper water is the only motive power for the quartz mills. In consequence of all this, the natural conclusion was that the yield for 1877 would be far smaller than that of the previous year. This apprehension appears the more warrantable, because, during the year, the whole list of mining shares sunk lower and remained depreciated longer than had ever before been the case. It appears, however, as if there were some other ground for this continued depreciation of the stock besides the unproductiveness of the mines, and the reason is probably to be found in the fact that there was a great lack of money among the speculating public and a consequent inability to buy; for if the newly-issued reports are in any way to be credited, the bullion yield in 1877 was not inferior to that of the previous year. In California, New Mexico, Montana, British Columbia, and Mexico the total yield is, to be sure, somewhat behind that of 1876, but the difference is comparatively small. It may, therefore, be concluded that the loss caused by scarcity of water has been made good by the discovery of new mines and the enlargement of old ones, and that, had it not been for this drawback, the yield would have been far higher, as Nevada, Utah, Arizona, Oregon, Washington, Idaho, Colorado, and Dakota, where rain and snow were plentiful, have larger returns to show. These remarks are followed in the report by the detailed estimate of the probable yield, amounting to $94,421,754, which has already been given. The quicksilver product amounted to 78,600 flasks. In consequence of the low prices the production of many of the mines was intentionally reduced. A combination of the principal quicksilver mining companies succeeded in bringing the price up to 62½ cents for a short time, but the average was about 42 cents per pound.

Apprehensions owing to scarcity of water.

Depreciation of mining stocks.

Silver production.

Up to 1859 resulted from the parting of gold.

"Some data respecting the silver production of the United States have already been given in connection with the gold yield for the same period. It is confessed on all sides that up to the year 1859 the silver yield of the United States arose almost exclusively from the parting of gold, and was of very small importance. Since the discovery and opening of the rich silver mines of Nevada, however, it has obtained a much greater importance, especially since the opening of the Comstock Lode, from which within a short time such enormous quantities of silver have been produced as was never before known since the best days of the mines of Potosi and one or two Mexican mines. The silver yield of the United States seems to have reached its maximum in the years 1875–'77. But large as the yield really was, the exaggeration usual in such cases was not lacking. For this reason there was a great variation in the estimates. This was the more natural, as at that time the fluctuations in the price of silver and the extraordinary reduction of the same aroused an unusual interest in the subject.

Bullion product of the United States.

Nevada mines.

Comstock lode.

"The board of commissioners appointed by the British Parliament on the 3d of March, 1879, to investigate the cause of the depreciation of silver, give, in their report dated July 3, of the same year, a detailed account of the development of the silver produce in the United States, and especially in regard to the years 1874–'76. They also collected a quantity of material in reference to this subject, which is published in the supplement to the report. The yield of several individual mines of the Comstock Lode are given; also the quotations and dividends of many of these mining enterprises, and various other details of the same character. The general statistical statements which were submitted to them, however, vary very much from one another, and the commissioners were, therefore, unable to come to a final decision as to which of the estimates was approximately the most correct. Many of the estimates give a presumptive silver yield in the United States in the year 1876 of about $50,000,000. There was an equally large and even an increasing yield anticipated until a correspondence from San Francisco, which was published in the 'Times,' put an end to such exaggerated representations. It is here stated with authority that the silver product in the United States in the year 1876 did not exceed 24,000,000 ounces fine silver or (the ounce being reckoned at $1.15) $27,600,000.

British Parliamentary investigation on the cause of depreciation in the value of silver.

"We had intended limiting ourselves to the brief notes already given in reference to the silver produce of the United States, regardless of the fact that so great a mass of detailed reports lie before us that many pages might be filled with them; a decisive reason for this limitation, however, is the appearance of a new special official report bearing the title 'Special Report to the United States Monetary Commission on the Recent and Prospective Production of Silver in the

Special report to the U. S. Monetary Commission.

Bullion product of the United States.

United States, particularly from the Comstock Lode,' Washington, February 24, 1877. This treatise is to be found in the supplement to the report of the aforementioned Silver Commission (vol. 1, pp. 1 to 60), which appointed Mr. Del Mar to examine into the bullion product at its source, in order to do away with the universal uncertainity in regard to the amount of the same.

Report of A. Del Mar.

Explanation of previous methods of estimating the annual bullion yield.

"Mr. Del Mar first explains the methods for estimating the annual bullion yield in the United States which had been in use up to that date. The "export and consumptions method" consisted in estimating the product according to the export schedules and the amounts which had been coined during the year. The results of this method are, however, most imperfect owing to the notorious untrustworthiness and incompleteness of the export statistics. The so-called "express method" consists in the estimates made by Mr. Valentine, superintendent of Wells, Fargo, & Co. Express, of the bullion produce of the mining district west of the Great Salt Lake, which is transported almost exclusively by this company. The ordinary statements which are published in the San Francisco papers are from this source, and are regarded by the commercial public as being more approximately accurate than the discordant published estimates; but, on the other hand, the objection is raised that considerable amounts of gold dust and ingots are brought to market from the interior without the express company being employed, and that ores which frequently contain bullion are usually sent as ordinary freight by rail, and that, therefore, in these cases Mr. Valentine is unable to do more than merely calculate the probabilities. It is also very possible that the same amount may be twice stated, which would of course unduly increase the estimate. Furthermore, the auriferous silver is stated simply as silver, and, therefore, in the declarations which have heretofore been made, the gold product is put down at too low a figure and the silver product at more than it should be.

The "exports and consumptions" method.

The "express" method.

The "bank" method.

"The 'bank method' is the estimate which is gained from a combination of the returns of three banks of San Francisco, through whose hands almost the entire silver product of California and Nevada is put upon the market. In criticising this method it was pointed out that it would be possible to gain a trustworthy estimate of the bullion yield of the United States in this way if all the assayers were obliged by law to declare the results of their assays to the Treasury, as all the gold and silver obtained in the United

States, down to trifling sums, are tested for their alloy either in the mints or by private assayers. Bullion product of the United States.

"To ascertain the bullion yield of Nevada the 'assessor's method' may also be employed. According to a law of this State, made in 1864, a yearly tax is levied on the mines of about 1 per cent. of the amount of their net proceeds, and as a check, statements of the gross proceeds must be made quarterly. Mr. Del Mar is convinced that with one or two trifling exceptions, such as the omission of the quarterly declaration on the part of small mining enterprises, and concerning the reworking of ores, the estimates of the bullion yield of Nevada gained in this way may be regarded as accurate. Report of A. Del Mar. The "assessor's" method.

"Mr. Del Mar made use of a new and independent method of valuation suggested to him by Senator Jones, president of the Silver Commission. Mr. Jones has large mining interests in Nevada, and is well acquainted with the state of affairs there. This method consists in extracting from the bullion books of the various mining companies their output. There are certain difficulties connected with this method: the number of small mining enterprises is large; the fiscal year of the various companies differs; and, finally, in early days the gold and silver yield was not entered separately upon the bullion books of many of the companies. It was possible to overcome these difficulties, however, though not without much labor. It is said, to the credit of the mining companies, that the desired information was always given with great readiness, and the tax-lists of Nevada were of service in supplementing and verifying the reports. Senator Jones method.

"On account of the insufficiency of time and assistance, these detailed and statistically comprehensive investigations could not be extended to any extent beyond the limits of Nevada up to the date of publication. That State, however, furnishes the preponderating part of the entire product. For the present only the returns for the years 1871–'76 have been given. The necessary material for the reports of the preceding years, 1861–'70, has already been extracted from the bullion books, but not yet worked up. This will, however, be done subsequently. Geographical limitation of the statement up to date of publication.

Bullion product of the United States.

"The results of Mr. Del Mar's investigations are as follows:

Result of Del Mar's investigation.

Gold and silver product of the United States.

	Districts.	1871.		1872.	
		Gold product.	Silver product.	Gold product.	Silver product.
1871–1872.	Comstock Lode	$4,077,427	$6,250,587	$6,310,035	$6,612,943
	Other mines in Nevada	1,485,007	7,880,764	2,142,730	9,953,634
	Whole of Nevada	5,562,434	14,111,351	8,452,765	16,566,577
	Remainder of the United States	....	4,000,000	....	2,000,000
	Entire silver product	....	18,111,351	....	18,566,577
		1873.		1874.	
1873–1874.	Comstock Lode	10,493,756	11,037,020	12,579,825	11,881,000
	Other mines in Nevada	2,678,469	8,094,440	1,650,202	3,521,382
	Whole of Nevada	13,172,225	19,131,460	14,230,027	15,402,382
	Remainder of the United States	....	6,000,000	....	10,000,000
	Total silver product	....	25,131,460	....	25,402,382
		1875.		1876.	
1875–1876.	Comstock Lode	11,739,873	14,492,350	18,002,906	20,570,078
	Other mines in Nevada	2,256,618	6,717,636	1,337,798	7,462,752
	Whole of Nevada	13,996,491	21,209,986	19,340,704	28,032,830
	Remainder of the United States	....	9,000,000	....	10,151,520
	Total silver product	....	30,209,986	....	38,184,350

Silver product of the U. S. (excepting Nevada): 1876.

"The silver product in the United States (with the exception of Nevada) is given for 1876 as follows:

Utah	$3,351,520
Colorado	3,000,000
California	1,800,000
Arizona	500,000
Montana	800,000
Idaho	300,000
New Mexico	400,000
Total, about	10,151,520

Reason for giving a variety of statements and authorities.

"The bullion yield in the United States is of such importance that it has been considered best to give in detail the principal estimates and valuations, however much they may differ from one another. From this material any one who takes an interest in the matter can form his own opinion on the subject.

Bullion product of the United States.

Dr. Soetbeer's conclusions.

RECAPITULATION.

Periods.	No. of years.	Gold product.			Silver product.		
		Total.	Yearly average.	Value.	Total.	Yearly average.	Value.
		Kilos.	*Kilos.*	*Marks.*	*Kilos.*	*Kilos.*	*Marks.*
1804–'20...	17	60	3.5	9,800	.....	....	....
1821–'30...	10	1,100	110	306,900	....	....	....
1831–'40...	10	8,500	850	2,371,500	....	....	....
1841–'50...	10	176,000	17,600	49,104,000		...	....
1851–'55...	5	444,000	88,800	247,752,000	41,500	8,300	1,494,000
1856–'60 ..	5	385,500	77,100	215,109,000	31,000	6,200	1,116,000
1861–'65...	5	333,500	66,700	186,093,000	870,000	174,000	31,320,000
1866–'70...	5	380,000	76,000	212,040,000	1,505,000	301,000	54,180,000
1871–'75...	5	297,500	59,500	166,005,000	2,824,000	564,800	101,664,000

TOTAL YIELD.

1821–'50...	30	185,600	....	517,824,000	5,271,500	....	948,870,000
1851–'75 ..	25	1,840,500	....	5,134,995,000	....	....	
1821–'75 ..	55	2,026,100	....	5,652,819,000	....	....	....

"The above table gives in German money and metrical weight, the estimates which we ourselves consider the most accurate."

JAMES D. HAGUE,
Additional Commissioner.