Iron Oxide Pigments

By Cynthia T. Collins[1]

Production and trade in finished iron oxide pigments were up in 1978, owing to continued strong demand for pigments in building materials, industrial coatings, and commercial paints. A decline in the construction and automotive industries in 1979 resulted in lower demand for pigments. Total U.S. production for the year increased, however, owing to the first full year of production by Mobay Chemical Corp. The first stage of Mobay's new synthetic iron oxide pigment plant at New Martinsville, W. Va., was completed in the third quarter of 1978. Production began late in the year, and shipments started early in 1979. The final stage of the 45,000-ton-per-year capacity plant was scheduled for completion late in 1980.

Early in 1979, Pfizer Inc. completed an expansion at its Easton, Pa., plant where production capacity for copperas red pigment was increased by 25%. Cities Service Co. formed a new subsidiary, Columbian Chemicals Co., in 1979. Production and sales of iron oxide pigments are now functions of the latter company. Capacity of the Columbian Chemicals plant at Monmouth Junction, N.J., was expanded by 20% in 1979. Chemetron Corp., a wholly owned subsidiary of Allegheny Ludlum Industries Inc., sold its Pigments Division to BASF Wyandotte Corp., the U.S. branch of the BASF AG Group of the Federal Republic of Germany. The transaction included the synthetic iron oxide pigment plant at Huntington, W. Va. In 1978 Mineral Pigments Corp. phased out production of natural iron oxide pigments made from raw materials. The company now markets only blends made from purchased pigments.

In December 1978, the Dry Color Manufacturers' Association established a committee of iron oxide pigment producers to conduct a literature search on the safety of iron oxide. The committee intends to issue a position paper for the industry and provide documentation that iron oxide is not a carcinogen.

Table 1.—Salient iron oxide pigments statistics in the United States

	1975	1976	1977	1978	1979
Mine production short tons	43,335	66,848	59,233	84,796	87,869
Crude pigments sold or used do.	40,154	59,636	55,953	75,967	74,548
Value thousands	$1,093	r$1,626	r$2,143	$2,799	$2,578
Iron oxides from steel plant wastes short tons	19,252	21,403	r21,024	20,924	25,186
Value thousands	$1,102	$1,258	r$1,644	$1,396	$1,703
Finished pigments sold short tons	104,840	135,915	140,707	152,510	156,036
Value thousands	$46,206	$64,506	$73,851	$81,830	$94,175
Exports short tons	8,780	5,805	6,493	7,064	4,852
Value thousands	$2,523	$3,353	$4,065	$6,649	$7,359
Imports for consumption short tons	27,979	50,102	58,694	70,549	55,377
Value thousands	$9,184	$16,554	$20,596	$24,706	$24,341

rRevised.

DOMESTIC PRODUCTION

Table 2 reflects sales data compiled from responses by 19 companies (see table 3) to the Bureau of Mines annual canvass. This represents 95% coverage of all companies that produce finished natural and/or synthetic iron oxide pigments from raw materials. The increase in production in 1979 was due to the entrance into the domestic market of Mobay Chemical Corp.'s new synthetic pigment plant in West Virginia. The gain in 1979 production was partially offset by the loss of natural oxide production from Mineral Pigments Corp.; also, a softening of demand in the last quarter of the year resulted in slight decreases in annual sales for some companies.

Domestic mine production of crude iron oxide pigments is shown in table 1, and producers are listed at the end of table 3. Cleveland-Cliffs Iron Co. closed the Mather underground iron mine at Negaunee, Mich., on July 31, 1979. Ore from the mine and associated beneficiating plants was used principally in pig iron production, but crude hematite was also shipped annually for pigments. The mine was the principal domestic producer of crude iron oxide pigments for many years.

Five steel companies produced byproduct iron oxide from plant wastes in 1978-79. Regenerated oxide from spent pickle liquor was used principally in the manufacture of ferrites, and some was used for pigments in industrial coatings. About one-third of the iron oxides derived from flue dust were used as a foundry sand additive, one-third in welding electrode manufacture, and one-third in fertilizer production.

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kind

Pigment	1978		1979	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Natural:				
Black: Magnetite	10,707	$1,219	8,075	$906
Brown:				
Iron oxide[1]	8,151	2,260	10,075	3,481
Umbers:				
Burnt	5,546	2,868	4,495	2,665
Raw	2,040	936	1,782	970
Red:				
Iron oxide[2]	40,476	3,596	40,618	3,953
Sienna, burnt	665	416	647	464
Yellow:				
Ocher[3]	7,588	913	6,865	945
Sienna, raw	745	380	683	399
Total natural[4]	75,918	12,588	73,240	13,782
Synthetic:				
Brown: Iron oxide[5]	11,351	10,364	11,404	11,319
Red: Iron oxides	26,433	25,267	33,344	32,540
Yellow: Iron oxide	25,916	22,725	24,550	22,651
Other: Specialty oxides	8,969	7,951	10,291	12,053
Total synthetic[4]	72,669	66,307	79,590	78,563
Mixtures of natural and synthetic iron oxides	3,923	2,935	3,205	1,830
Grand total[4]	152,510	81,830	156,036	94,175

[1]Includes Vandyke brown.
[2]Includes pyrite cinder.
[3]Includes yellow iron oxide.
[4]Data may not add to totals shown because of independent rounding.
[5]Includes synthetic black iron oxide.

Table 3.—Producers of iron oxide pigments in the United States in 1978-79

Producer	Mailing address	Plant location
Finished pigments:		
BASF Wyandotte Corp	100 Cherry Hill Rd. Parsippany, N.J. 07054	Wyandotte, Mich.; Huntington, W. Va.
Blue Ridge Talc Co., Inc	Box 39 Henry, Va. 24102	Henry, Va.
Chemalloy Co., Inc	Box 350 Bryn Mawr, Pa. 19101	Bryn Mawr, Pa.
Cities Service Co., Columbian Div. (Became Columbian Chemicals Co. in 1979).	Box 300 Tulsa, Okla. 74102	St. Louis, Mo.; Monmouth Junction, N.J.; Trenton, N.J.
Combustion Engineering, Inc., CE Minerals Div.	901 East 8th Ave. King of Prussia, Pa. 19406	Camden, N.J.
DCS Color & Supply Co., Inc	1050 East Bay St. Milwaukee, Wis. 53207	Milwaukee, Wis.
E. I. du Pont de Nemours & Co., Inc.	Pigments Dept. Wilmington, Del. 19898	Newark, N.J.
Ferro Corp., Ottawa Chemical Div.	700 North Wheeling St. Toledo, Ohio 43605	Toledo, Ohio.
Foote Mineral Co	Route 100 Exton, Pa. 19341	Exton, Pa.
Hoover Color Corp	Box 218 Hiwassee, Va. 24347	Hiwassee, Va.
Mineral Pigments Corp. (Discontinued iron oxide production in 1978).	7011 Muirkirk Rd. Beltsville, Md. 20705	Beltsville, Md.
Mobay Chemical Corp.	Penn Lincoln Parkway West Pittsburgh, Pa. 15205	New Martinsville, W. Va.
New Riverside Ochre Co	Box 387 Cartersville, Ga. 30120	Cartersville, Ga.
Pfizer Inc., Minerals, Pigments & Metals Div.	235 East 42d St. New York, N.Y. 10017	Emeryville, Calif.; East St. Louis, Ill.; Easton, Pa.
Prince Manufacturing Co	700 Lehigh St. Bowmanstown, Pa. 18030	Quincy, Ill.; Bowmanstown, Pa.
Reichard-Coulston Inc	15 East 26th St. New York, N.Y.10010	Bethlehem, Pa.
George B. Smith Chemical Works, Inc.	1 Center St. Maple Park, Ill. 60151	Maple Park, Ill.
St. Joe Minerals Corp.	7733 Forsyth Blvd. Clayton, Mo. 63105	Sullivan, Mo.
Solomon Grinding Service	Box 1766 Springfield, Ill. 62705	Springfield, Ill.
Sterling Drug, Inc., Hilton-Davis Chemicals Div.	2235 Langdon Farm Rd. Cincinnati, Ohio 45237	Cincinnati, Ohio.
Crude pigments:		
Cleveland-Cliffs Iron Co., Mather Mine & Pioneer Plant (Closed July 31, 1979).	1460 Union Commerce Bldg. Cleveland, Ohio 44115	Negaunee, Mich.
Hoover Color Corp	Box 218 Hiwassee, Va. 24347	Hiwassee, Va.
St. Joe Minerals Corp. Pea Ridge Mine	7733 Forsyth Blvd. Clayton, Mo. 63105	Sullivan, Mo.
New Riverside Ochre Co	Box 387 Cartersville, Ga. 30120	Cartersville, Ga.

CONSUMPTION AND USES

Demand for iron oxide pigments in industrial coatings and building materials was strong in 1978 and continued to hold up in the first half of 1979. However, demand for pigments in those end uses declined in the latter half of the year, reflecting the downturn in the automotive and construction industries. Demand for the pigments from trade sales paints increased in 1978 and continued strong in 1979. This was due partly to the continued popularity of colors derived from iron oxides; deep browns, reds, russets, and muted golds and tans were popular shades for exterior paints.[2] Trends in interior house paints included a renewed interest in the neutral beige and tan shades, along with continued popularity of yellows, golds, and pinks.[3] A strong market for furniture in 1978 led to continued demand for sienna and some transparent oxides used in wood stains, but this market declined slightly in the last half of 1979. Use of yellow iron oxide in highway marking paints increased in some States where lead chromate pigments have been banned.

As shown in table 4, high-purity iron oxides were also consumed in a variety of other applications. They were used for their magnetic properties in the manufacture of permanent magnets, ferrites for electronic components, magnetic ink, and coatings for recording tape. Iron oxide pigments were also used as colorants in the manufacture of plastics, rubber, paper, textiles, glass, and

ceramics; as a trace element in cattle feed and coloring for pet food and fertilizer; as a hot-strength binder in foundry sands; as an industrial catalyst; and as an ingredient in fluxes used in the production of welding rods and electrodes.

Table 4.—Percent of iron oxide consumption, by end use

End use	All iron oxides		Natural iron oxides		Synthetic iron oxides	
	1978	1979	1978	1979	1978	1979
Coatings (industrial finishes, trade sales paints, varnishes, lacquers)	34.0	38.0	24.0	26.0	44.0	48.0
Construction materials (cement, mortar, preformed concrete, roofing granules)	20.5	21.0	24.0	23.0	17.0	18.0
Ferrites and other magnetic and electronic applications	13.0	11.0	12.0	10.0	14.0	11.0
Colorants for plastics, rubber, paper, textiles, glass, ceramics	7.0	10.0	2.0	7.0	11.5	12.0
Industrial chemicals (such as catalysts)	8.5	7.0	7.0	6.0	9.5	9.0
Animal feed and fertilizers	9.0	8.0	18.0	17.0	1.0	1.0
Foundry sands	5.0	4.0	11.0	9.0	--	--
Other (including cosmetics and jeweler's rouge)	3.0	1.0	2.0	2.0	3.0	1.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

PRICES

Prices increased in September 1978 for most natural and synthetic iron oxides. The price of micaceous iron oxide jumped 15 cents per pound, but other increases ranged from 1 cent per pound for synthetic red and Vandyke brown to 5 cents per pound for metallic and synthetic browns. Another round of price increases occurred in October and November 1979 when synthetic browns and yellows as well as Vandyke brown and ocher were raised again. Synthetic black iron oxide, unchanged since 1977, rose by more than 10 cents per pound.

Table 5.—Prices quoted on finished iron oxide pigments, per pound, bulk shipments

Pigment	December 31, 1978		December 31, 1979	
	Low	High	Low	High
Black:				
Synthetic	$0.3100	$0.3825	$0.4300	$0.4900
Micaceous	.5500	--	.5500	--
Brown:				
Ground iron ore	.1000	.1300	.1000	.1300
Metallic	.1550	.1850	.1550	.1850
Pure, synthetic	.4700	.5000	.5000	.5250
Sienna, Italian, burnt	.3400	.4850	.3400	.4850
Umber, Turkish, burnt	.2600	.2900	.2600	.2900
Vandyke brown	.2725	.3025	.3450	--
Red:				
Domestic primers	.2025	.2325	.2025	.2325
Pure, synthetic	.4350	.4650	.4350	.4650
Spanish	--	.2625	.2625	--
Yellow:				
Synthetic	.4250	.4350	.4750	.4800
Ocher, domestic	.1275	--	.1450	--

Source: American Paint Journal.

FOREIGN TRADE

In January 1978, the Tariff Schedules of the United States (TSUSA) were revised to show import breakdowns of synthetic iron oxides by color. The new categories are reflected in table 7 for 1978 and 1979. However, it is believed that some imports in the early months of 1978 were improperly classified in the "other" category because of unfamiliarity with the new breakdowns. As classifications became more accurate, the "other" category was reduced. The data for 1979 are thought to be reasonably accurate.

The reduction in imports from the Federal Republic of Germany in 1979, shown in table 8, was due largely to the onset of domestic production by Mobay Chemical Corp. Previously, the company's sales of synthetic iron oxide were imports from Mobay's parent company, Bayer AG. The drop in imports from Canada in 1979 may

Table 6.—U.S. exports of iron oxides and hydroxides, by country

Destination	1978				1979			
	Pigment grade		Other grade		Pigment grade		Other grade	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	6	$34	74	$212	13	$25	7	$8
Australia	154	207	114	308	272	337	329	799
Belgium-Luxembourg	45	67	19	20	19	103	39	43
Brazil	175	289	140	263	238	388	64	137
Canada	3,365	1,543	1,932	1,163	1,756	1,696	4,050	2,214
Colombia	37	39	73	179	41	48	12	11
Costa Rica	3	3	13	6	6	5	14	9
Denmark	55	123	31	53	46	189	3	2
Dominican Republic	2	2	19	22	9	11	7	7
Ecuador	9	12	9	19	24	36	15	36
Egypt	--	--	--	--	21	17	--	--
El Salvador	5	11	--	--	1	5	1	2
Finland	43	27	--	--	62	51	2	6
France	119	163	107	194	74	144	342	887
Germany, Federal Republic of	47	52	398	1,058	41	63	364	889
Guatemala	11	15	5	4	14	15	--	--
Hong Kong	363	386	18	22	72	78	29	45
India	8	19	22	47	1	5	12	28
Indonesia	25	65	23	72	39	118	--	--
Iran	--	--	--	--	--	--	23	13
Israel	15	6	2	1	(1)	1	--	--
Italy	582	881	65	127	289	681	218	411
Jamaica	8	11	--	--	8	22	--	--
Japan	196	526	788	1,655	206	646	1,431	3,136
Korea, Republic of	169	303	213	585	402	624	183	461
Liberia	18	14	--	--	15	14	--	--
Mexico	179	94	329	603	69	89	379	551
Netherlands	49	108	1,498	1,907	73	159	4,028	2,857
New Zealand	18	13	(1)	2	9	12	2	3
Pakistan	--	--	--	--	--	--	75	116
Philippines	18	21	--	--	38	36	--	--
Poland	10	45	--	--	--	--	3	14
Portugal	(1)	1	60	200	4	7	5	22
Seychelles	--	--	--	--	--	--	12	26
Singapore	24	23	150	230	26	45	17	56
South Africa, Republic of	31	36	(1)	5	16	31	1	3
Spain	11	18	2	6	36	45	(1)	1
Sweden	7	19	14	15	39	139	7	9
Switzerland	5	7	24	48	1	2	4	27
Taiwan	188	71	19	24	105	185	302	233
Thailand	--	--	--	--	7	6	18	21
United Kingdom	813	1,048	664	1,590	505	994	585	1,337
U.S.S.R	--	--	407	750	--	--	--	--
Venezuela	208	286	31	40	206	227	89	68
Yugoslavia	--	--	14	24	--	--	--	--
Other	43	61	21	50	48	60	19	21
Total[2]	7,064	6,649	7,298	11,505	4,852	7,359	12,691	14,508

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 7.—U.S. imports for consumption of selected iron oxide pigments

Pigment	1978		1979	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Natural:				
Crude:				
Siennas	612	$176	287	$133
Umbers	7,970	608	6,831	615
Other	100	54	74	168
Total[1]	8,683	839	7,191	916
Finished:				
Ochers	2	(2)	3	2
Siennas	184	61	178	77
Umbers	1,393	356	736	242
Vandyke brown	951	282	798	259
Other	1,324	256	1,350	302
Total[1]	3,853	956	3,064	882
Synthetic:				
Black	16,671	1,979	9,439	1,975
Red	9,876	5,248	8,148	4,469
Yellow	9,361	5,981	12,143	8,513
Other[3]	22,104	9,703	15,390	7,587
Total[1]	58,013	22,912	45,121	22,543
Grand total[1]	70,549	24,706	55,377	24,341

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Includes synthetic brown oxides, transparent oxides, and magnetic, and precursor oxides.

Source: U.S. Bureau of the Census.

Table 8.—U.S. imports for consumption of iron oxide and iron hydroxide pigments, by country

Country	Natural				Synthetic			
	1978		1979		1978		1979	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	59	$31	118	$70	--	--	--	--
Belgium-Luxembourg	--	--	21	7	118	$52	252	$120
Brazil	--	--	--	--	--	--	20	4
Canada	48	10	24	10	24,377	3,403	16,614	3,383
Cyprus	8,827	735	7,268	731	5	3	--	--
France	(1)	1	(1)	2	28	76	15	25
Germany, Federal Republic of	876	243	794	277	27,674	16,736	22,122	14,882
India	--	--	20	1	--	--	--	--
Italy	481	172	405	190	--	--	(1)	2
Japan	44	46	47	141	2,786	1,328	3,059	2,792
Mexico	--	--	--	--	994	367	1,261	524
Netherlands	122	57	(1)	1	242	79	830	224
South Africa, Republic of	--	--	2	1	--	--	--	--
Spain	1,179	191	1,176	217	12	4	56	26
United Kingdom	889	304	380	152	1,779	862	891	560
Other	11	4	--	--	--	--	1	1
Total[2]	12,536	1,794	10,256	1,798	58,013	22,912	45,121	22,543

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

be due to the fact that their prices were increased to domestic levels early in the year. Imports from Canada are primarily byproduct iron oxides from regenerated steel plant pickle liquor.

According to the Bureau of the Census Schedule B, Statistical Classification of Domestic and Foreign Commodities Exported from the United States, January 1, 1978, exports shown in table 6 as "other grade" include synthetic iron hydroxide, iron oxide for catalysts, synthetic iron oxides (except pigment grade), and jeweler's rouge.

WORLD REVIEW

Table 9, showing mine production of natural iron oxide pigments by country, was adapted from table 1 in Bureau of Mines Information Circular 8813.[4] Data for the centrally planned economy countries were incomplete; therefore, no total for world mine production is shown. Data for foreign production of synthetic iron oxides were also incomplete.

Table 9.—Natural iron oxide pigments: World mine production, by country

(Short tons)

Country	1976	1977	1978[p]	1979[e]
Argentina	192	230	244	225
Australia	1,130	68	[e]55	55
Austria	11,714	10,808	11,640	11,000
Brazil	6,566	7,308	[e]7,400	7,700
Burma	679	254	508	440
Canada	--	--	--	3,000
Chile	7,651	8,979	6,132	6,600
Cyprus	11,201	13,776	14,000	13,000
Egypt	3,590	35	270	110
France	12,152	[e]12,000	[e]12,000	14,000
Germany, Federal Republic of[1]	25,177	29,124	23,672	27,500
India	101,471	83,704	80,722	82,700
Iran[2]	5,057	3,858	[e]2,200	1,100
Italy[e]	2,200	1,900	1,500	1,100
Morocco	15	39	[e]30	30
Pakistan	17,411	15,774	5,150	1,100
Paraguay	132	132	165	110
Portugal	44	68	[e]70	65
South Africa, Republic of	2,658	2,392	2,411	2,400
Spain:				
Ocher	9,902	13,630	[e]13,500	13,200
Red iron oxide	29,929	39,971	[e]26,500	27,500
United States	66,848	59,233	84,796	87,869

[e]Estimate. [p]Preliminary.
[1]Includes Vandyke brown.
[2]Iranian calendar year (March 21 to March 20), beginning in year stated.

TECHNOLOGY

The use of iron oxides for coloring is often determined by the other characteristics they possess. Because of the nontoxic nature of the oxides, they are used in plastics, paper, glass, and ceramics processed into food containers. Ceramic glazes were studied in an effort to determine the extent to which the release of silicon and boron in the glaze was a function of the coloring oxide additives. The results indicated that iron oxide pigments affect silicon and boron leaching only slightly; their effect was much less than that of chromium oxide.[5]

The divalent iron content of ferrites is important in determining their magnetic properties; therefore, an accurate method is needed for the determination of the amount of divalent iron present in large quantities of trivalent iron. A method was reported that determined the amount of divalent iron with a high degree of accuracy in many samples of NiZnCo and MnZn ferrites.[6]

Ferrites in small particles have been developed for use in the manufacture of explosives where they may enable law enforcement officials to determine illegal users. The ferrites act as magnetic tags in the explosives by identification of the temperature at which they lose their magnetism. Up to 3,000 different magnetic codes may be produced by rearrangement of the proportions of iron, zinc, and nickel in the ferrites, which results in different Curie points.[7]

Sintering of the powdered oxides is a necessary process in the manufacture of ferrites; therefore, the study of oxides during sintering is valuable in understanding their behavior. Research was reported in which the agglomeration of iron oxides during low-temperature sintering was studied. Submicrometer-size magnetic powders were monitored for surface area variations during sintering in vacuum and in air at different temperatures. In the low-temperature ranges studied (773°K, 793°K, and

843°K), it was shown that the oxidation rates of the magnetite in air altered the agglomerating time, while no phase changes were detected in vacuum-sintered powders.[8]

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[1]Mineral specialist, Section of Ferrous Metals.

[2]American Paint & Coatings Journal. Rich Colors in Nature Hues Lead 1978 Preferred List. V. 62, No. 47, May 1, 1978, pp. 49-50.

[3]American Paint & Coatings Journal. Color Likes Becoming More Conservative. V. 63, No. 8, Sept. 4, 1978, pp. 49-50.

—. Talks on Dispersants, Color Trends, Open Chicago Society's 1979-1980 Season. V. 64, No. 16, Oct. 8, 1979, p. 11.

[9]Jolly, J. L. W., and C. T. Collins. Iron Oxide Pigments (In Two Parts). Part 2. Natural Iron Oxide Pigments—Location, Production, and Geological Description. BuMines IC 8813, 1980, 79 pp.

[5]Buldini, P. L. Influence of Coloring Oxides in the Release of Silicon and Boron From Ceramic Glazes. Ceram. Bull., v. 57, No. 4, April 1978, pp. 430-431.

[6]Gallagher, P. K. A Coulometric Analysis of Iron (II) in Ferrites Using Chlorine. Ceram. Bull., v. 57, No. 6, June 1978, pp. 576-578.

[7]Chemical & Engineering News. Magnetic Tags for Explosives Developed. V. 58, No. 3, Jan. 21, 1980, p. 26.

[8]Kramer, C. M., and R. M. German. Low-Temperature Sintering of Iron Oxides. J. Am. Ceram. Soc., v. 61, No. 7-8, July-August 1978, pp. 340-342.