



# 2013 Minerals Yearbook

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## IRON OXIDE PIGMENTS [ADVANCE RELEASE]

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# IRON OXIDE PIGMENTS

By Arnold O. Tanner

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In 2013, natural crude iron oxide pigment (IOP) production in the United States was virtually unchanged compared with that of 2012, but actual U.S. production data are withheld to avoid disclosing company proprietary data. Finished natural and synthetic IOPs sold by processors decreased slightly to 47,200 metric tons (t) valued at \$75.4 million in 2013 from 48,400 t valued at \$77.7 million in 2012 (table 1). Exports of pigment-grade iron oxides decreased to 8,170 t valued at about \$13.4 million in 2013 compared with 8,950 t valued at \$13.5 million in 2012. Exports of other grades of iron oxides and hydroxides increased to 58,500 t valued at about \$34.9 million in 2013 compared with 51,400 t valued at \$41.9 million in 2012 (table 3). Imports of natural and synthetic IOPs combined increased to 165,000 t valued at \$190 million in 2013 compared with 151,000 t valued at \$182 million in 2012 (tables 1, 4, and 5).

Natural IOPs are inorganic compounds that are suitable for use as pigments after milling and minimal processing. They commonly are the preferred choice of the natural minerals for pigmentation because they are low cost, inherently color stable, and nontoxic. Typically, they are derived from hematite, which is a red iron oxide mineral; goethite or limonite, minerals that vary from yellow to brown, which include ochers and siennas (yellow) and umbers (brown); and magnetite, a black iron oxide mineral.

A wider variety of colors can be produced from natural IOPs by blending various IOPs or by calcination of hydrated natural IOPs. Synthetic IOPs are widely used as colorants and compete with natural IOPs in many color applications, in part because colors can be more precisely duplicated and a wider variety of colors are available. They are manufactured using the following three methods: thermal decomposition of iron salts or iron compounds; precipitation of iron salts, usually accompanied by oxidation; and reduction of organic compounds by iron. Organic colorants can be used for some colorant applications but they tend to fade over time from exposure to sunlight.

## Production

Domestic production data for natural crude IOPs were derived from voluntary responses to a U.S. Geological Survey (USGS) canvass of three domestic producers. U.S. production data for crude (natural) IOPs sold or used in 2013 were estimated on the basis of the data of one company and estimated for two nonrespondents on the basis of previously reported data adjusted according to industry trends. These data are withheld to avoid disclosing company proprietary data. It was estimated that production remained unchanged in 2013.

In a second voluntary USGS survey, sales data for finished (natural and synthetic) IOPs were received from five of eight

known processing operations, representing nearly 60% of the tonnage shown in table 1. Data for the nonrespondents were estimated on the basis of prior-year sales levels, employment hours, and industry trends. Sales of finished pigments were 47,200 t in 2013, down slightly from 48,400 t in 2012. Sales data for finished IOPs were collected only from operations that process material, such as the crushing and grinding of natural IOPs, or that synthesize IOPs, not operations that simply blend, mix, repack, and (or) resell IOP material.

At least four U.S. companies, operating nine plants, produced regenerated iron oxide during steelmaking (table 2). Iron oxide is obtained during steelmaking when steel is treated with hydrochloric acid to remove surface oxides. Iron oxide is separated from the spent pickle liquor when it is treated to recycle the acid and reduce waste. Regenerated iron oxide data were not included in table 1 because the iron oxides are not natural (mined), are not synthetic (manufactured), and must undergo additional processing before being suitable for use in typical IOP applications.

Applied Minerals, Inc.'s Dragon Mine property in Utah contains high-purity iron oxide consisting of hematite, goethite, and limonite along with halloysite clay, and the total measured iron oxide resource was 3.3 million metric tons (Mt). In 2013, Applied Minerals began production of IOPs at a 10,000-metric ton-per-year (t/yr) processing plant near the mine that was converted from processing halloysite clay. The company marketed its advanced IOP products [high iron oxide ( $\text{Fe}_2\text{O}_3$ ) content, chemical purity, and color saturation and low heavy metals content] under the AMIRON™ trade name (Applied Minerals, Inc., 2013; 2014).

Rockwood Pigments NA, Inc. began construction of its new \$115 million synthetic IOP production plant, near Augusta, GA. Operations at the advanced technology facility, previously planned for mid-2013, were expected to begin in February 2015. Construction of the new plant, which would be the first new synthetic IOP production plant built in the United States in nearly 35 years, had been delayed by adverse weather conditions and a change in engineering firms. Following completion of the Georgia plant, the company was expected to close its existing plant in St. Louis, MO, and part of its Beltsville, MD, facility (Martin, 2013).

Texas-based Huntsman Corp., a global specialty chemical company, agreed to purchase Rockwood Pigments, Titanium Dioxide Pigments, Inc., and three other businesses from Rockwood Holdings, Inc. for \$1.33 billion. For the previous year ending June 30, the color pigments portions of the businesses accounted for about \$330 million in sales. Following regulatory approvals in Europe and the United States, the transaction was expected to close by mid-2014 (Esposito, 2013).

## Consumption

In 2013, consumption of IOPs likely remained unchanged from 2012 as the world production numbers were similar. IOPs were used in construction materials, including concrete products such as block, brick, or segmental retaining wall units; mortar; paving stones; precast products of various sizes or dimensions; ready-mixed concrete; and roofing tiles; almost exclusively to color decorative concrete. The tinted concrete is often stamped to resemble brick, slate, stone, and many more shapes and forms found in nature, including wood (Pinto, 2008, p. 4, 6).

The second largest market for IOPs is as a tint in paints and coatings. Other IOP end uses included colorants for ceramics, glass, paper, plastics, rubber, and textiles; in foundry sands; industrial chemicals, such as catalysts; animal feed; cosmetics; ferrites; fertilizers; and magnetic ink and toner.

A major end use for regenerator iron oxides was ferrite ceramic magnets. Two types of ferrites are used—hard, which retain magnetism permanently, and soft, which do not. Hard ferrites are used in flexible magnets, generators, loudspeakers, and motors. Uses of soft ferrites include computers, cores for radio frequency coils, microwave communication systems, microwave ferrites for telecommunications, and other industrial applications. Other end uses of regenerator iron oxides include color pigments in construction materials, cosmetic preparations, dyes and paints, and plastic products.

## Prices

The annual average producer price index (PPI) for IOPs (U.S. Bureau of Labor Statistics Series ID WPU06220206) was 226.4 in 2013 compared with 220.7 in 2012. The PPI ranged between 225.9 and 227.5 in 2013, the high being reached in October through December and the low in January through February. The PPI measured the average change in the selling prices charged by domestic producers of IOPs over time (U.S. Bureau of Labor Statistics, 2014). Unit values for finished natural and synthetic IOP reported by domestic producers ranged from \$0.33 to \$3.81 per kilogram, with an average unit value of \$1.60 per kilogram.

## Foreign Trade

In 2013, U.S. exports of pigment grade and other iron oxides and hydroxides combined increased by 10.6%. Nearly 57% of total IOP exports went to China, which was almost four times that of the next highest country, Spain, with nearly 15% of the total (table 3).

U.S. exports of pigment-grade iron oxides decreased by 8.7% to 8,170 t valued at \$13.4 million in 2013, but the unit value increased by nearly 9%. Mexico was the leading destination, accounting for more than 52% of U.S. exports, and China was second with 18% (tables 1, 3). Exports of other grades of iron oxides and hydroxides increased by nearly 14% to 58,500 t in 2013, with a total value of \$34.9 million. China, Spain, and Canada were, in descending order, the major destinations for export of other grades of IOPs and hydroxides, accounting for 62%, 17%, and 9% of the export tonnage, respectively (table 3).

U.S. imports of all IOPs and hydroxides increased by about 10% in 2013 from those of 2012, and were 55% higher than the recent low of 2009 (tables 1, 4).

Imports of natural IOPs increased slightly. The leading source was Cyprus, with 68% of the tonnage, followed by France with 16%, and Austria, 11%. Imports of synthetic IOPs increased by nearly 10%. The leading sources of synthetic IOP imports were China with 51% of the tonnage; Germany, 27%; Canada, 8%; Brazil, 7%, and Italy, 5% (table 5).

## World Review

Natural IOPs were produced in at least 10 countries in 2013 (table 6). Several other countries were thought to produce iron oxide pigments, but output, which may have been substantial, was not reported, and no basis was available for estimating output levels.

Because many of Europe's IOP producers supplied external markets, they were not expected to be affected significantly by sluggish European construction markets. In general, IOP companies with a global customer base were less vulnerable to regional economic fluctuations. Consumption of pigment minerals was expanding significantly for certain emerging markets, such as Latin America and Asia, especially China (Ollett, 2013c).

**Austria.**—In 2013, Kärntner Montanindustrie GmbH continued production of micaceous iron oxide (MIO) from its underground mine in Waldenstein, Austria, accounting for up to 90% of the global MIO market. MIOs have a horizontal layering of flaky, lamellar, “micaceous” particles that overlap like scales on a fish and give strength and corrosion resistance to paints and coatings. Standard-grade MIOs are used on bridges, oil rigs, and other structural steel, and as protective coatings on electrical and industrial equipment. Micronized grades are used in anticorrosive decorative coatings, including water-based coatings; in prime coatings, as partial replacement of zinc dust; and in certain applications requiring a degree of friction (O'Driscoll, 2012; Kärntner Montanindustrie GmbH, 2014).

**China.**—China likely increased its IOP production beginning in about 2006, as partly evidenced by a steady and substantial decrease in IOP imports from the United States to a negligible quantity in 2009, despite the country's ongoing urbanization. In 2010–13, IOP imports from the United States increased to 37,700 t, returning to more than 85% of the average annual level for 2005–07 (U.S. International Trade Commission, undated). The increase in demand for IOPs in China mainly was driven by increased construction activity (table 3).

Hong Kong-based Cathay Industries Group and the Tonghua Group planned to construct a state-of-the-art synthetic iron oxide plant for the production of black, red, and yellow IOPs in Tonglin, Anhui Province, in eastern China. When completed, the joint-venture plant, to be known as Rely Science & Technology Co., Ltd., would have a 100,000-t/yr capacity with plans to expand to 150,000 t/yr. Products would be targeted for markets in China, which had been increasing at a rate of 7% to 8% per year in most IOP-consuming industries. The new plant would use a direct precipitation process, in which an all-liquid phase

method was expected to significantly reduce liquid and solid waste. This plant would be Cathay Industries' eighth IOP plant in China. Its other major plants are in Shenzhen, Guangdong Province, and Shanghai and Wuxi, Anhui Province (Cathay Industries Group, 2013; Ollett, 2013a).

Lanxess AG began construction of a 25,000-t/yr red IOP plant at the Ningbo Chemical Park in Ningbo, Zhejiang Province, at an estimated cost of \$74 million; production was planned to begin in early 2015. The new plant was being built with particular emphasis being placed on water treatment, waste gas cleaning, and energy consumption. Lanxess also operated a 38,000-t/yr IOP plant in Jinshan, Shanghai Province, where it produced yellow and black iron oxide pigments (Lanxess AG, 2013; Ollett, 2013b, c).

**Spain.**—Promindsa SA, the country's leading producer of IOPs, produced and sold nearly 15,400 t of IOPs in 2013, down from 16,000 t in 2012, 85% of which was exported to more than 50 countries. The company expected production and sales of about 15,100 t in 2014. About 80% of Promindsa's IOP output and sales was red hematite. Promindsa sold its Santa Rosa iron oxide as a red pigment for use in asphalt, brick, glass and ceramics, paints, and roof tile. Promindsa also mined black (magnetite), brown (oolitic iron ore), and yellow (goethite) IOPs in Spain. The company was developing the Ojos Negros Mine project, which was scheduled to commence production of 1,000 t/yr of brown IOP from goethite iron ore in July 2014 (Fernando Prada, President, Promindsa SA, written commun., June 30, 2014; Moores, 2010).

## Outlook

Although the global economic situation was improving, construction activity and consequent consumption of IOPs for coloring concrete and paint remained sluggish. On a world scale, growth in the IOP market is expected to continue to increase during the next several years, mostly because of increased construction activity in China, Latin America, and the United States. In Europe, because economic uncertainties have continued following the regional debt crisis, capital spending on construction projects that use IOPs is expected to vary by region and country and to be limited overall (Ollett, 2013b).

The International Monetary Fund expected the global economy to increase by about 3.6% in 2014 and 3.9% in 2015, with emerging and developing economies continuing to increase by more than twice the percentage as that of the advanced economies (International Monetary Fund, 2014). Continued improvement in the global economy may result in increased activity in IOP markets in 2014–15, especially in regions where the construction industry is expanding.

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TABLE 1  
 SALIENT U.S. IRON OXIDE PIGMENTS STATISTICS<sup>1</sup>

		2009	2010	2011	2012	2013
Crude pigments sold or used: <sup>2</sup>						
Quantity	metric tons	W	W	W	W	W
Value	thousands	W	W	W	W	W
Finished pigments sold: <sup>3</sup>						
Quantity	metric tons	50,800	54,700	48,000	48,400	47,200
Value	thousands	\$74,000	\$80,700	\$73,900	\$77,700	\$75,400
Exports: <sup>4</sup>						
Quantity	metric tons	5,640	8,750	8,660	8,950	8,170
Value	thousands	\$15,500	\$15,700	\$15,000	\$13,500	\$13,400
Imports for consumption: <sup>3</sup>						
Quantity	metric tons	106,000	151,000	158,000	151,000	165,000
Value	thousands	\$127,000	\$167,000	\$188,000	\$182,000	\$190,000

W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Data are rounded to no more than three significant digits.

<sup>2</sup>Mined.

<sup>3</sup>Natural (mined) and synthetic.

<sup>4</sup>Pigment grade.

TABLE 2  
 PRODUCERS OF IRON OXIDE PIGMENTS AND REGENERATED IRON OXIDES  
 IN THE UNITED STATES IN 2013

Producers	Plant location
Pigments:	
Crude:	
Alabama Pigments Co., LLC	Green Pond, AL.
Hoover Color Corp.	Hiwassee, VA.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Finished:	
Alabama Pigments Co., LLC	Green Pond, AL.
Dynamic Color Solutions, Inc.	Milwaukee, WI.
Hoover Color Corp.	Hiwassee, VA.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Prince Minerals, Inc.	Quincy, IL; and Bowmanstown, PA.
Rockwood Pigments NA, Inc.	Beltsville, MD; Cartersville, GA; King of Prussia, PA; Los Angeles, CA; and St. Louis, MO.
Regenerator iron oxides:	
American Iron Oxide Co. <sup>1</sup>	Allenport, PA; Portage, IN; and Rockport, IN.
ArcelorMittal Weirton Inc.	Weirton, WV.
Bailey-PVS Oxides, LLC	Decatur, AL; Fairfield, AL; and Delta, OH.
International Steel Services, Inc.	Burns Harbor, IN; and Warren, OH.

<sup>1</sup>Division of International Steel Services, Inc.

TABLE 3  
U.S. EXPORTS OF IRON OXIDES AND HYDROXIDES, BY COUNTRY<sup>1</sup>

Country	Pigment grade				Other grade			
	2012		2013		2012		2013	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	19	\$15	2	\$17	5	\$60	76	\$41
Australia	89	238	120	334	400	297	959	338
Belgium	765	3,090	789	3,720	396	935	68	324
Brazil	100	421	139	817	197	316	287	275
Canada	19	40	2	4	7,350	12,900	5,070	9,540
Chile	334	641	95	228	41	65	246	152
China	2,640	2,900	1,510	2,530	23,300	10,900	36,200	12,500
Colombia	45	304	109	270	489	522	29	64
France	16	77	36	221	36	632	2	22
Germany	3	7	5	22	2,050	1,280	839	505
Haiti	7	26	4	14	5	22	6	26
Hong Kong	44	163	50	167	65	106	10	27
India	92	292	65	210	102	404	79	332
Indonesia	3	23	3	22	76	117	(2)	8
Israel	19	61	16	43	802	272	101	39
Italy	11	77	162	129	--	--	33	89
Jamaica	15	41	16	19	4	10	17	40
Japan	21	89	3	8	25	19	27	32
Korea, Republic of	39	243	73	411	36	628	35	587
Malaysia	--	--	62	35	15	29	6	30
Mexico	3,900	2,590	4,280	2,730	2,790	3,960	2,560	1,840
Netherlands	1	3	2	5	67	171	36	116
Singapore	11	71	1	7	68	374	84	183
South Africa	35	128	14	89	7	48	3	6
Spain	21	85	7	39	11,700	4,060	9,860	2,480
Taiwan	146	263	2	11	134	813	90	523
Thailand	9	61	104	288	22	794	639	2,140
Trinidad and Tobago	5	15	1	10	18	84	5	16
United Arab Emirates	20	11	41	22	201	127	141	114
United Kingdom	287	967	131	508	531	1,340	615	1,790
Venezuela	15	48	172	165	246	140	231	101
Other	217 <sup>r</sup>	523 <sup>r</sup>	156	341	169 <sup>r</sup>	448 <sup>r</sup>	200	557
Total	8,950	13,500	8,170	13,400	51,400	41,900	58,500	34,900

<sup>r</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Less than ½ unit.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 4  
U.S. IMPORTS FOR CONSUMPTION OF SELECTED IRON OXIDE AND HYDROXIDE PIGMENTS, BY TYPE<sup>1</sup>

Type	2012		2013		Principal sources, 2013 (metric tons)
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)	
Natural:					
Earth colors <sup>3</sup>	1,930	\$984	2,270	\$1,200	Cyprus, 2,270.
Micaceous	1,340	1,420	1,070	1,110	France, 545; Austria, 353; Spain, 129.
Total	3,280	2,400	3,340	2,310	
Synthetic:					
Black	40,500	41,900	47,700	46,600	Germany, 14,500; China, 13,100; Canada, 12,800.
Red	59,600	72,500	60,500	70,700	China, 40,200; Germany, 17,500.
Yellow	46,200	62,600	53,000	69,000	China, 28,000; Germany, 11,000; Brazil, 10,800.
Other <sup>4</sup>	1,350	2,390	743	1,620	China, 495; Canada, 108.
Total	148,000	179,000	162,000	188,000	
Grand total	151,000	182,000	165,000	190,000	

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Customs value.

<sup>3</sup>Includes those not elsewhere specified or included.

<sup>4</sup>Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

Source: U.S. Census Bureau.

TABLE 5  
U.S. IMPORTS FOR CONSUMPTION OF IRON OXIDE AND IRON HYDROXIDE PIGMENTS, BY COUNTRY<sup>1</sup>

Country	Natural				Synthetic			
	2012		2013		2012		2013	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Austria	196	\$303	353	\$408	16	\$42	1	\$2
Belgium	--	--	--	--	7	4	8	24
Brazil	--	--	--	--	9,160	12,700	10,800	15,100
Canada	--	--	--	--	9,810	3,440	13,500	3,940
China	28	25	23	19	75,800	86,300	81,800	88,200
Colombia	--	--	--	--	2,440	3,690	2,400	3,610
Cyprus	1,880	886	2,270	1,100	--	--	--	--
France	478	388	545	443	114	682	131	995
Germany	277	316	--	--	37,900	48,400	43,600	57,900
Italy	121	86	3	10	9,310	17,400	7,440	13,300
Japan	3	35	1	90	1,630	4,930	1,210	3,610
Spain	275	314	129	153	309	198	389	241
Other	19	53	20	86	1,170 <sup>r</sup>	1,640 <sup>r</sup>	696	1,060
Total	3,280	2,410	3,350	2,310	148,000	179,000	162,000	188,000

<sup>r</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Customs value.

Source: U.S. Census Bureau.

TABLE 6  
 NATURAL IRON OXIDE PIGMENTS: ESTIMATED WORLD PRODUCTION, BY COUNTRY<sup>1,2</sup>

(Metric tons)

Country <sup>3</sup>	2009	2010	2011	2012	2013
Austria, micaeous iron oxide	3,000 <sup>r</sup>	3,500 <sup>r</sup>	3,500 <sup>r</sup>	3,500 <sup>r</sup>	3,500
Cyprus, umber	4,363 <sup>4</sup>	4,500	4,000	4,000	4,000
France	2,800	2,800	2,800	17,800	18,000
Germany <sup>5,6</sup>	209,172 <sup>4</sup>	233,909 <sup>4</sup>	223,288 <sup>4</sup>	204,198 <sup>4</sup>	205,000
India, ocher	1,136,000 <sup>r,4</sup>	1,229,000 <sup>r,4</sup>	1,320,000 <sup>r,4</sup>	1,400,000 <sup>r</sup>	1,400,000
Italy	105 <sup>4</sup>	117 <sup>4</sup>	112	118 <sup>r</sup>	100
Pakistan, ocher	55,985 <sup>4</sup>	45,715 <sup>r,4</sup>	39,303 <sup>r,4</sup>	40,000	45,000
South Africa	183 <sup>4</sup>	244 <sup>4</sup>	266 <sup>4</sup>	-- <sup>r,4</sup>	--
Spain, ocher and red iron oxide	17,000	15,500 <sup>4</sup>	15,000 <sup>4</sup>	16,500 <sup>4</sup>	16,400
United States	W	W	W	W	W

<sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

<sup>1</sup>Estimated data are rounded to no more than three significant digits, unless otherwise noted.

<sup>2</sup>Includes data available through May 6, 2014.

<sup>3</sup>In addition to the countries listed, a number of others produce iron oxide pigments, but output is not reported and no basis is available for formulating estimates of output levels. Such countries include Azerbaijan, Brazil, China, Honduras, Iran, Kazakhstan, Lithuania, Paraguay, Russia, Turkey, Ukraine, and the United Kingdom. Unreported output is probably substantial.

<sup>4</sup>Reported figure.

<sup>5</sup>Accurate information concerning exactly how much of this production translates into iron oxide pigments is not available.

<sup>6</sup>Production includes natural and synthetic iron oxide pigments.