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USGS revision of global iron ore production data—Clarification of the reporting of iron ore production in China and application of a uniform comparison methodology (2000-2015)

By Candice C. Tuck, Sean Xun, and Sheryl A. Singerling

Iron ore is the source of primary iron for the world's iron and steel industries. Its production can be reported as crude ore, usable ore, or iron content of ore. Historically, the U.S. Geological Survey (USGS) used reported crude ore production from China in tabulations of world iron ore production while other countries have typically reported their production in terms of usable iron ore. When China's crude ore production was tabulated with usable ore production from other countries, world iron ore production totals have been overestimated by 10% to a high of 32% (figures 1, 2). The significant increase in iron ore production in China during the period from the year 2000 through 2015 amplified the overestimation resulting from tabulating inconsistent forms of the material. Sources of data for usable iron ore production in China, beginning in the year 2000, have become available. This paper documents the revision of world iron ore production totals and to augment historical China iron ore production figures to show both crude and usable ore values.

Terminology

- Crude ore refers to ore extracted from the ground that has not been processed or concentrated (beneficiated) to increase its iron content. The iron content of mined iron ore can range from less than 10% in low-grade deposits to more than 60% in high-grade deposits.
- Usable ore (or finished ore) refers to ore that can be used directly in a downstream process. Usable iron ore typically contains from 58% to 65% iron (Fe) content and may include products such as concentrates, direct-shipping ore, pellets, and sinter.
- Iron content, also referred to as metal content or grade, denotes the amount of elemental iron in the crude or usable ore.

Background

Iron ore consumed in the steel industry typically require an iron content greater than 58% before being considered commercially usable. Iron ores that are not commercially usable must undergo beneficiation to raise the iron content. Approximately 98% of the world's usable iron ore production is consumed in blast furnaces to make pig iron, which is further processed to make steel.

High-grade iron ore mines can supply usable iron ore, known as direct-shipping ore, to blast furnaces, with minimal physical processing and no beneficiation. With direct-shipping ore, the reported production for crude ore and usable ore are the same. Ore from low-grade deposits must undergo beneficiation to increase the iron content before it can be used by the steel industry. In this instance, the mined material is called crude ore and post-beneficiation production is called usable ore. The amount of finished ore produced will be less than the crude ore. With the notable exceptions of countries such as Australia and Brazil, most of the world's iron ore deposits are low-grade and require beneficiation.

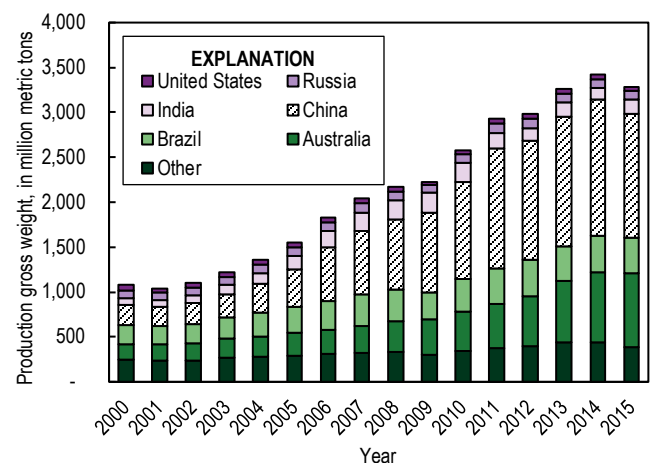


Figure 1. Iron ore production, on a usable basis, for select countries, with China reported on a crude ore basis, from 2000 through 2015

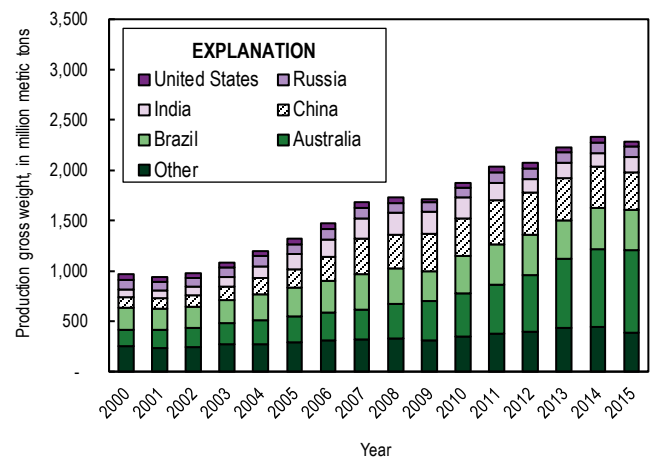


Figure 2. Iron ore production, on a usable basis, for select countries from 2000 through 2015.

Differences in Iron Ore Reporting

Crude Ore

Crude ore is not reported by most countries as it is an intermediate product, although some countries use crude ore for tax calculations. In China, iron ore typically ranges from 10% to 35% Fe. Among member companies of the China Iron and Steel Association (CISA), predominantly large-scale producers, the average grade of crude ore was 28.8% in 2014 and members accounted for 21% of China's iron ore production in 2013 (China Steel Yearbook Editorial Board, 2015). Among non-CISA members, believed to be mostly small and State-sponsored iron ore mines, the iron content of crude ore can vary greatly from year to year. Relatively small mines may begin operation when demand is high and (or) the price of iron ore increases. Certain mines may be State sponsored and their rate of production is at the discretion of the Government, as opposed to market conditions.

Consequently, China's reported crude ore production was used because an average reserve grade or assumed mill-head grade was not available to estimate usable ore for most years.

Usable Ore

Usable ore for making iron and steel typically ranges from 58% to 65% Fe. Because of this narrow range of iron content, usable ore provides a more uniform basis for comparison and tabulation of global iron ore production.

For countries with deposits that are considered high-grade, such as Australia and Brazil, usable iron ore production consists primarily of direct-shipping ore. Direct-shipping ore may be crushed for ease of transportation, but not chemically modified before sale. The iron content for these products typically ranges from 58% to 60%. In countries with mid- and low-grade deposits, the crude ore is beneficiated to produce iron concentrates with ideal iron contents greater than 60% (Association for Iron and Steel Technology, 1999). The concentrates may be further processed with binders to create iron ore pellets, which provide a chemical and thermal benefit in blast furnace smelting. There are several variations of these products, such as fines, flux pellets, and sinter; however, all are considered usable ore.

The CISA reports usable ore production for China in the China Steel Yearbook in addition to crude ore production sourced from the National Bureau of Statistics of China, the same source cited by the USGS for crude iron ore production for China. Even though their members represent only a portion of China's production, the data purport to cover China's total production of usable ore. In 2013, CISA reported that the average grade of iron ore concentrates was 61.8% Fe.

CISA also reported that concentrates accounted for 98% of the total usable ore produced in China for that year (China Steel Yearbook Editorial Board, 2015). Using CISA data for China's usable iron ore production, the USGS has revised its iron ore data series back through 2000. As shown in figures 1 and 2 and table 1, iron ore production for China and world production totals decrease dramatically using usable ore production instead of crude ore production.

Table 1. Revised China and world production of crude ore, usable iron ore, and iron content¹.

[Million metric tons]

Year	Crude Ore		Usable Ore		Iron Content ²	
	China	World Total	China	World Total	China	World Total
2000	223	1,080	112	969	69	610
2001	211	1,040	108	937	67	591
2002	233	1,100	115	982	71	621
2003	263	1,210	127	1,080	79	679
2004	320	1,360	156	1,200	97	758
2005	420	1,550	186	1,320	115	839
2006	597	1,830	237	1,470	147	942
2007	707	2,040	345	1,680	214	1,070
2008	780	2,170	339	1,730	210	1,080
2009	885	2,220	374	1,710	232	1,070
2010	1,080	2,580	371	1,870	230	1,170
2011	1,340	2,930	442	2,030	274	1,240
2012	1,330	2,980	420	2,070	261	1,280
2013	1,450	3,280	417	2,230	259	1,370
2014	1,510 ³	3,430	410 ⁴	2,330	254	1,430
2015	1,380 ³	3,290	375 ⁴	2,280	232	1,400

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

²Iron content is calculated as 62% percent of usable ore.

³Data reported by the National Bureau of Statistics of China.

⁴Estimated; reported figures were not available at the time of publication.

Iron Content

Iron content might be considered a preferable method of tabulating global production; however, the iron content of usable iron ore production is seldom reported except as a general ratio for annual production. The variations in iron ore deposits and mining plans can result in fluctuations in iron grades for crude ore and for usable ore produced throughout the year at an operation. Iron ore is typically sold in quantities of hundred thousand tons with only an average chemical composition obtained from sampling of the ore. For this reason, using the average iron content for an entire operation or country may not be available or representative of the actual production.

In calculating the annual iron content of China's iron ore production, the USGS previously used the iron content of the reported reserves, which was reported as 31% in 2000. Extrapolating crude ore production reported by the National Bureau of Statistics of China and usable ore production reported by CISA across the 15-year period, the USGS calculated that the grade of China's crude ore trended downward from 31% Fe in 2000 to 18% Fe in 2013.

USGS Reporting of Global Production

Owing to increased steel demand in China, small-scale miners with lower-grade deposits were brought into production to meet domestic iron ore demand. As the production share of large-scale and established miners decreased, average ore grades decreased. Ore grades at the large-scale mines were higher, which, along with economies of scale, made their operations economic. The share of crude ore production from China's Iron and Steel Association members decreased, from 47% in 2000 to 21% in 2013.

In tabulations of world production, the USGS previously reported the National Bureau of Statistics China's data for iron ore production in China and footnoted the data as being crude ore production. China reached unprecedented levels of iron ore production and consumption for the country, driven by steel production, as the economy of China grew at unprecedented rates during the first decade of the new millennium (Morrison, 2014). Iron ore was a critical material for the rapid rate of urbanization within China (United Nations, 2014).

Based on revised USGS data, from 2000 to 2002, China produced an average of 12% of global usable iron ore. Beginning in 2003, the previously stable level of China's production began to increase (table 2). From 2002 to 2013, China increased usable ore production from 115 to 417 million metric tons (Mt). By comparison, the crude ore production in China increased from 233 Mt in 2002 to 1.45 billion metric tons (Gt) in 2013. The percentage increase in production during the time period from 2002 to 2013 was 263% for usable ore and 522% for crude ore. The large differences in the percentages reflect the falling grade of crude ore produced over this period.

The increasing discrepancy resulting from the different reporting basis on world totals is apparent in Tables 1 and 2. As Chinese crude ore production increased, the world production totals became increasingly overestimated. The percent difference in world totals calculated with China on a crude ore basis compared with a usable ore basis was 11% in 2002 and 32% in 2013.

When reporting world production tabulated with China's usable ore, China's share of global iron ore production rose from 12% in 2000 to an estimated 16%

in 2015. In previously reported world production totals using China's crude ore production, China's share of global iron ore production rose from 21% in 2000 to an estimated 42% in 2015. Based on usable ore, China's share of the global increase in iron ore production from 2000 to 2014 was only 6% compared with 30% when calculated using crude ore.

Similarly, the share of world production for iron ore-producing countries is affected by the differences in reporting standards. When reporting China on a usable-ore basis, Australia was the world's leading producer in 2013 with 31% of world production, whereas China and Brazil constituted 19% and 17%, respectively. When reporting China on a crude ore basis, China was the world's leading producer in 2013 with a 44% share of world production; Australia and Brazil's share was reduced to 21% and 12%, respectively.

Conclusion

The USGS is revising its iron ore production data for China from the year 2000 forward by including usable ore in addition to crude ore and calculating the world total based on China usable ore production. Prior to 2000, data for usable iron ore for China are unavailable, and the data series will still be reported and footnoted as crude ore. Additionally, iron contents based on usable ore have been revised from the year 2000 forward. If iron content for China is reported in future CISA or other publications, the USGS will use that figure for its calculations of specific annual production totals.

Beginning with the Iron Ore chapter of the 2014 USGS Minerals Yearbook, volume I, Metals and minerals, and the Iron Ore Chapter of the Mineral Commodity Summaries 2017, world iron ore production totals will be tabulated using China usable ore and estimated iron-content basis for all countries.

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Table 2. Production of usable iron ore for the world's top producers.¹

[Million metric tons]

Year	Usable Iron Ore							World Total
	Australia	Brazil	China	India	Russia	United States	Other	
2000	168	213	112	76	87	63	251	969
2001	182	202	108	79	83	46	237	937
2002	188	215	115	86	84	52	242	982
2003	213	231	127	99	92	49	270	1,080
2004	234	262	156	121	97	55	275	1,200
2005	262	282	186	152	97	54	287	1,320
2006	275	318	237	177	102	53	309	1,470
2007	299	355	345	207	105	53	318	1,680
2008	342	351	339	214	100	54	331	1,730
2009	394	299	374	218	92	27	306	1,710
2010	433	372	371	207	95	50	344	1,870
2011	488	398	442	169	104	56	377	2,030
2012	556	401	420	137	104	55	399	2,070
2013	683	387	417	152	102	53	436	2,230
2014	774	411	410 ²	129	102	56	445	2,330
2015	817	397	375 ²	156	101	46	390	2,280

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

²Estimated; reported figures were not available at the time of publication.