MARKET REPORT

ON

TUNGSTEN, FLUORSPAR, BISMUTH AND COPPER

SOMERLEY LIMITED

Corporate Finance Advisers

AUGUST 2011

Disclaimer

This report is prepared by Somerley Limited ("Somerley") to provide information on the four minerals of tungsten, fluorspar, bismuth and copper for Masan Group Corporation (the "Company").

It is specifically acknowledged by the Company that the report on tungsten, fluorspar, bismuth and copper (the "Report") is the intellectual property of Somerley. Somerley acknowledges that the Company intends to use the Report in marketing materials/prospectuses for capital-raising purposes. The Company and each recipient of the Report acknowledge that copyright of the Report strictly belongs to Somerley. In the event of any breach or infringement of copyright, the party who is held liable should compensate Somerley for all losses and damages in respect of such breach or infringement of copyright.

The content of this Report herein is based on information believed to be accurate. However, Somerley assumes no responsibility to any party for any errors or inaccuracy. The Report has been prepared based on numerous public and private sources information and has not been independently verified by Somerley. Neither Somerley nor any of its affiliates, directors, officers, employees, agents, consultants or advisors make or give any express or implied statement, guarantee, representation or warranty to any party concerning the accuracy, assumptions, reliability or completeness of the information in the Report.

All parties, including the Company and recipients of the Report, must rely upon their own assessment of the information and carry out their own due diligence enquiries as to the accuracy and completeness of the information in the Report. Any reliance placed by the Company and the recipients on the information shall be at their own risk. All parties, including the Company and recipients of the Report, should seek appropriate and independent professional advice in reviewing the information and evaluating business opportunities with the Company and/or providing finance (whether equity or debt) to the Company. They should conduct their own independent investigation and assessment of the content of the Report and make such additional enquiries and verifications, as they deem necessary or appropriate.

All warranties, conditions, liabilities or representations, whether express or implied, written, oral, collateral, statutory or otherwise in relation to the information, advice or other service constituted by this Report are hereby expressly negated and excluded to the extent permitted by law. Somerley and its affiliates, directors, officers, employees, agents, consultants or advisors disclaim all liabilities in relation to such warranties, conditions, statements or representations in respect of the information in the Report. All parties including the Company and recipients of the Report acknowledge and agree that they shall not seek any remedy (whether legal or equitable) or make any claims from Somerley and its affiliates, directors, officers, employees, agents, consultants or advisors in any respect whether in contract, negligence, equitable relief, statutory relief or otherwise by reason of provision of the information or otherwise in connection with this Report.

In furnishing the information, Somerley does not undertake any obligation to provide the Company with access to any additional information or corrections for any inaccuracies in the Report. All parties including the Company and recipients of the Report acknowledge that circumstances, market conditions and/or assumptions may change and the content of this Report may become outdated as a result. In addition, statements or assumptions in this Report as to future matters are subject to uncertainty and may prove to be incorrect. It is important for all parties, including the Company and recipients of the Report, to conduct their own independent investigations and assessments of this Report and make their own independent enquiries and verifications as they deem necessary or appropriate.

The Report is not to be construed as an offer or the solicitation of an offer to buy or sell any security in the Company or provide finance (whether equity or debt) to the Company. Recipients of the Report should conduct their own independent investigations and assessment of this Report and make their own independent enquiries and verifications as they deem necessary or appropriate. Independent professional advice including tax advice should be sought before any decision or commitment is made.

If the Company and/or any party does not accept any of the terms stated above, this Report must be immediately returned to Somerley. Failure to return this Report to Somerley will be deemed to be an acceptance of Report by such party, including the disclaimer by Somerley.

Table of Contents

Part I: Tungsten 9

1. Introduction to Tungsten and Properties 9
   - 1.1. Properties of Tungsten 9
   - 1.2. Occurrence 9
2. Value Chain of the Tungsten Industry 10
3. Global Tungsten Supply Analysis 12
   - 3.1. Global Tungsten Reserves 12
   - 3.2. Global Tungsten Production 13
   - 3.3. China's Tungsten Supply 15
   - 3.4. Major Tungsten Producers 16
   - 3.5. Secondary Consumption 18
   - 3.6. Expected Changes in Supply 18
4. Global Tungsten Demand Analysis 20
   - 4.1. Tungsten Demand by Product 20
   - 4.2. Tungsten Demand by Region 21
5. China Dynamics 26
   - 5.1. China's Demand and Supply Balance 26
   - 5.2. China's Policies 26
6. Pricing 28

Part II: Fluorite 30

1. Introduction to Fluorite and Properties 30
   - 1.1. Properties of Fluorite 30
   - 1.2. Occurrence 30
   - 1.3. Fluorite Grades and Uses 30
2. Value Chain of the Fluorite Industry 31
   - 2.1. Chemical Industry 32
   - 2.2. Building Materials Industry 32
   - 2.3. Metallurgy Industry 33
3. Global Fluorite Supply Analysis 34
   - 3.1. Global Fluorite Reserves 34
   - 3.2. Global Fluorite Production 35
   - 3.3. China's Fluorite Supply 38
   - 3.4. China's Hydrofluoric Acid Production 39
   - 3.5. China Fluorite Exports 42
4. Global Fluorite Demand Analysis 43
   - 4.1. Fluorite Demand Structure 43
5. China Dynamics 44
   - 5.1. China's Demand and Export Balance 44
   - 5.2. China's Policies 45
6. Pricing 47

Part III: Bismuth 49

1. Introduction to Bismuth and Properties ... 49
1.1. Properties of Bismuth ... 49
1.2. Occurrence and Extraction ... 49
1.3. Specifications of Bismuth ... 50
2. Value Chain of the Bismuth Industry ... 50
2.1. Bismuth Uses ... 51
3. Global Bismuth Supply Analysis ... 53
3.1. Global Bismuth Reserves ... 53
3.2. China's Bismuth Reserve ... 54
3.3. Global Bismuth Production ... 54
3.4. Expected Changes in Supply ... 56
4. Global Bismuth Demand Analysis ... 56
5. China Dynamics ... 57
6. Pricing ... 58
6.1. Historical Price ... 58
6.2. Demand-Supply Analysis ... 59

Part IV: Copper ... 60
1. Introduction to Copper and Properties ... 60
1.1. Properties of Copper ... 60
1.2. Occurrence ... 61
2. Value Chain of the Copper Industry ... 62
3. Global Copper Supply Analysis ... 63
3.1 Global Copper Reserves ... 63
3.2 Global Copper Production ... 64
3.3 Major Copper Producers ... 65
3.4 Trends in Production ... 67
3.5 Secondary Consumption ... 67
3.6 Expected Changes in Supply ... 68
4. Global Copper Demand Analysis ... 70
4.1 Copper Demand by Product and Country ... 70
4.2 Trends in Demand ... 72
4.3 Demand Drivers and Expected Changes in Demand ... 74
5. China Dynamics ... 74
5.1 Demand/Supply Balance and Trends ... 74
5.2 China's Policy ... 76
6. Pricing ... 77

Tables and Figures Index

Table I- 1: Properties of the main tungsten minerals 9
Table I- 2: World tungsten apparent mine production, 2006 – 2010 (tons of metal contained) 14
Table I- 3: Historical demand of tungsten by region (excluding China), 2006 – 2010 (tons of metal contained) 24
Table I- 4: China's tungsten supply and demand balance, 2008 – 2010 ('000 tons of metal contained) 26
Table I- 5: Other applicable taxes 27

Table II- 1: Fluorite category by calcium fluoride content 31
Table II- 2: Applications in the manufacture of building materials 33
Table II- 3: World major fluorite resources countries in 2010 34
Table II- 4: China's major fluorite deposits 35
Table II- 5: World fluorite production, 2005 – 2009 (in tons) 37
Table II- 6: Major fluorite producers in China 38
Table II- 7: Major hydrofluoric acid producers in China 40
Table II- 8: New hydrofluoric acid production by Chinese companies in the upcoming three years 41
Table II- 9: China's fluorite export quota, 2003 – 2010 46

Table III- 1: World mine production and reserves (tons of metal contained) 53
Table III- 2: The major players at each step of the value chain 54
Table III- 3: China bismuth export in 2010 55

Table IV- 1: Summary of copper's properties and related applications 61
Table IV- 2: TC/RC from 2006-2010 63
Table IV- 3: World major copper resources countries in 2010 64
Table IV- 4: World copper mine production ('000 tons) 65
Table IV- 5: Major copper company producers in the world 66
Table IV- 6：Expected world copper mine production capacity increase 69
Table IV- 7: World refined copper demand ('000 tons) 70
Table IV- 8: World copper consumption by major countries ('000 tons) 71
Table IV- 9: Copper consumption growth segments and countries 73
Table IV- 10: Major copper producers in China 75
Table IV- 11: China's copper concentrate supply/demand balance, 2003 – 2008 ('000 tons) 76

Figure I- 1: Tungsten value chain 11
Figure I- 2: Distribution of world tungsten reserves (tons of metal contained) 13
Figure I- 3: Tungsten apparent mine production of China vs. other countries in 2010 (tons of metal contained) 14
Figure I- 4: China's tungsten concentrate production cap vs. real output ('000 tons of concentrate) 15

Figure I- 5: China tungsten products export quota vs. actual export 16
Figure I- 6: Global primary tungsten demand by end-use sector in 2007: 21
Figure I- 7: China’s tungsten consumption structure in 2010 (tons of metal contained) 22
Figure I- 8: China tungsten consumption by product, 2008 – 2010 (tons of metal contained) 22
Figure I- 9: Production of metal cutting machine instruments in China, 2000 – 2009 (‘000 sets) 23
Figure I- 10: Production of numerical cutting metal machine instrument in China 2000-2009 (‘000 sets) 23
Figure I- 11: Compound annual growth rate of mechanical engineering equipment in China, 2003 – 2009: 24
Figure I- 12: Prices of China’s tungsten products 29

Figure I- 1: Tungsten value chain 11
Figure I- 2: Distribution of world tungsten reserves (tons of metal contained) 13
Figure I- 3: Tungsten apparent mine production of China vs. other countries in 2010 (tons of metal contained) 14
Figure I- 4: China's tungsten concentrate production cap vs. real output (‘000 tons of concentrate) 15
Figure I- 5: China tungsten products export quota vs. actual export 16
Figure I- 6: Global primary tungsten demand by end-use sector in 2007: 21
Figure I- 7: China’s tungsten consumption structure in 2010 (tons of metal contained) 22
Figure I- 8: China tungsten consumption by product, 2008 – 2010 (tons of metal contained) 22
Figure I- 9: Production of metal cutting machine instruments in China, 2000 – 2009 (‘000 sets) 23
Figure I- 10: Production of numerical cutting metal machine instrument in China 2000-2009 (‘000 sets) 23
Figure I- 11: Compound annual growth rate of mechanical engineering equipment in China, 2003 – 2009: 24
Figure I- 12: Prices of China’s tungsten products 29

Figure II- 1: Fluorite applications 31
Figure II- 2: Sketch map of fluorite mineral resource distribution in China 35
Figure II- 3: World fluorite annual production, 1913 – 2009 36
Figure II- 4: China's hydrofluoric acid production, 2003 – 2009 40
Figure II- 5: China's fluorite exports, 1995 – 2009 42
Figure II- 6: Global acid grade and metallurgical grade fluorite consumption, proportion and growth rates 43
Figure II- 7: Fluorite consumption structure by the developed world 43
Figure II- 8: US fluorite apparent consumption, 2005-2009 44
Figure II- 9: China's domestic fluorite consumption-export balance 45
Figure II- 10: China’s domestic fluorite consumption structure in 2009 45
Figure II- 11: China’s fluorite export prices (USD/ton) 47

Figure III- 1: Value chain of the bismuth industry 51
Figure III- 2: China bismuth export distribution in 2010 55

Figure III- 3: Bismuth ingot 99.99% FOB warehouse US (USD/lb)... 59

Figure IV- 1: Value chain of the copper industry. 62
Figure IV- 2: Copper mine production in the last century 64
Figure IV- 3: World secondary copper usage 67
Figure IV- 4: Copper consumption by industry 71
Figure IV- 5: Distribution of copper consumption growth in the 1980s....................................... 72
Figure IV- 6: Distribution of copper consumption growth in the 1990s....................................... 73
Figure IV- 7: Distribution of copper consumption growth, 2000-2020 73
Figure IV- 8: Historical copper price (USD/lb) 77

Part I: Tungsten

1. Introduction to Tungsten and Properties

1.1. Properties of Tungsten

Tungsten, also known as wolfram, is a chemical element with the chemical symbol W and atomic number 74. In tungsten's raw form, it is a steel-gray metal that is often brittle and hard to work; however, if pure, it can be worked easily. In metallic form, tungsten has many valuable properties. It has the highest melting point of all the elements with the exception of carbon. It has the lowest expansion coefficient of all metals and is extremely heavy. It has a very high modulus of compression and elasticity, and is consequently extremely hard.

The principal ores of tungsten contain the minerals scheelite or “white ore”, which is calcium tungstate, and wolframite or “black ore”, which is iron-manganese tungstate.

Table I- 1: Properties of the main tungsten minerals

	Scheelite	Wolframite
Formula	$CaWO_4$	$(Fe, Mn)WO_4$
Color	Golden yellow, brownish green, brown, pinkish to reddish gray, colorless	Black (ferberite) to brown (huebnerite)
Habit	Pesudo-octahedra, massive, columnar, granular	Tabular crystals, sometimes prismatic
System	Tetragonal	Monoclinic 2/m
Cleavage	Distinct, two directions	Perfect 010
Fracture	Subconchoidal to uneven – brittle	Uneven to rough
Hardness	4.5-5	4-4.5
Luster	Vitreous to adamantine	Submetallic to resinous
Streak	White	Black to brown
SG	5.9 - 6.1	7 - 7.5
Fusibility	With difficulty	3 - 4 to magnetic globule
Solubility	Soluble in acids	Insoluble

1.2. Occurrence

Tungsten is a comparatively rare mineral, accounting for only 0.00013% of the Earth’s crust. The largest tungsten deposits (>100,000 tons of tungsten) are concentrated in China, the former Soviet Union and Canada. More modest-sized deposits (10,000 to 100,000 tons of tungsten) are found in the United States, Australia, Brazil, Burma, Peru, North Korea, South Korea, Turkey, Thailand, Vietnam and some Western European countries. Despite its large size and diverse geology, Africa is particularly lacking in large known tungsten deposits, although there has been increasing volume exported from Africa in recent years from a number of small operations.

2. Value Chain of the Tungsten Industry

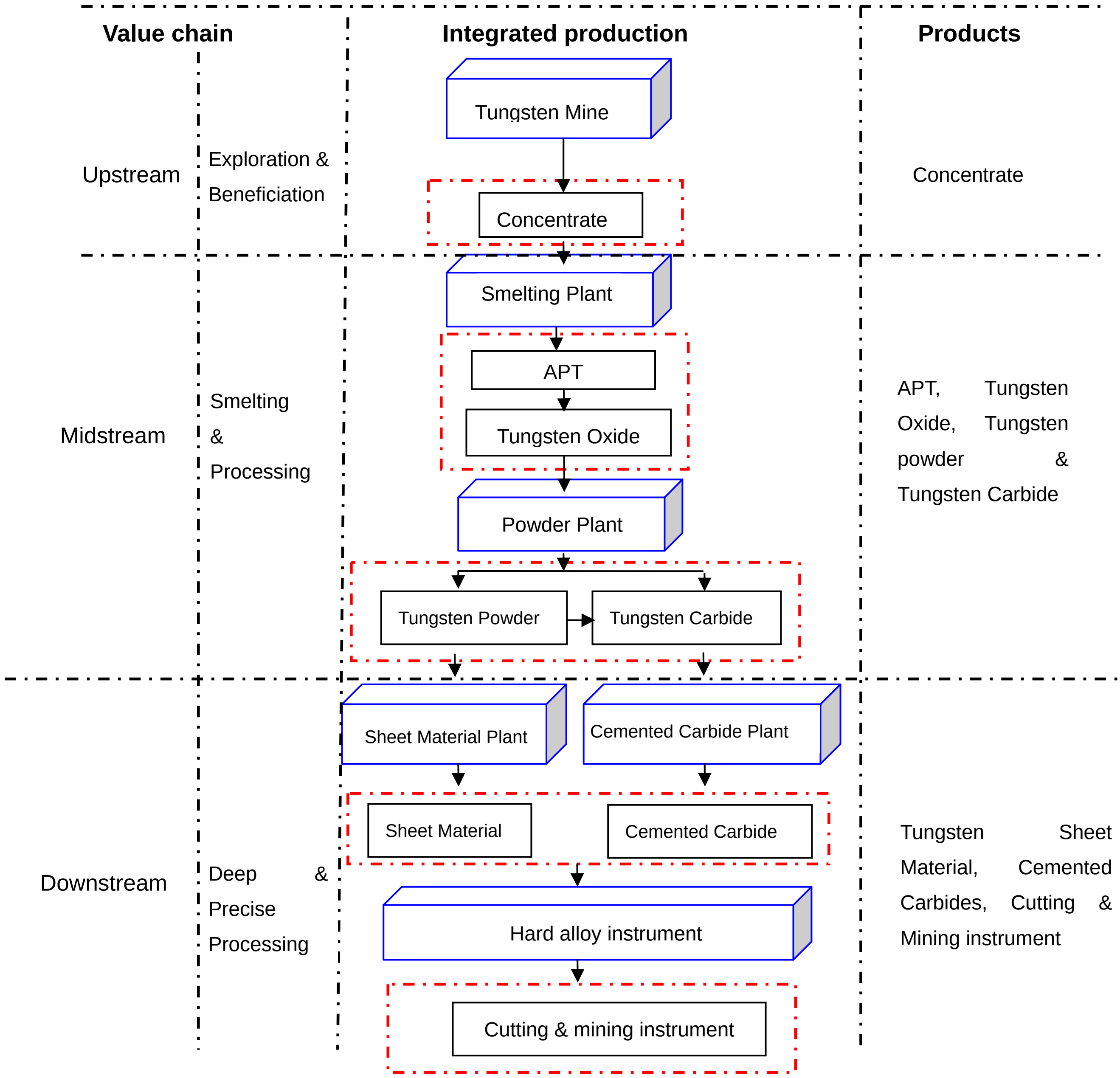
The value chain of the tungsten industry covers mine exploration, development, beneficiation, mineral smelting, product processing and deep/precise processing. Tungsten products are commonly classified into three categories:

a) Upstream: tungsten concentrate (contains 65%-70% WO_3),

b) Midstream: ammonium paratungstate (APT, contains 88.5% WO_3), tungsten oxide (contains 99.9% WO_3), tungsten powder, and tungsten carbide

c) Downstream: tungsten sheet material, tungsten steel, tungsten chemical products and cemented carbides, etc.

Figure I- 1: Tungsten value chain



Uses of Main Tungsten Products

- Concentrate: The ore is crushed and milled to liberate the tungsten mineral crystals. Scheelite ore is typically concentrated by gravimetric methods in combination with froth flotation, whilst wolframite ore is concentrated by gravity, often using magnetic separation. Marketable concentrates typically contain 65-70% tungsten oxide (WO_3). Concentrates were formerly the main traded product, but they have now been substituted by APT.

- Ammonium Paratungstate (APT): The initial process of separating tungsten from its ore produces APT. Marketable APT typically contains at least 88.5% WO_3. This is the most important precursor for the majority of tungsten products as it is easily converted to elemental tungsten powder via thermal decomposition, and to other tungsten chemicals via chemical processes.

- Tungsten Oxides: When calcined, APT forms a yellow, blue or brown oxide product. In recent years, an increasing proportion of traded tungsten is in the form of one of the oxides. Blue tungsten oxide is used primarily for the production of tungsten metal powder and tungsten carbide, and as a catalyst and promoter of catalysts in industrial chemical synthesis. Yellow tungsten oxide is mainly used in yellow glazes for ceramics and enamels, as a catalyst in the production of propyl alcohols, in ozone monitoring sensors, in lamps used in marine PEL sector lights, in optical interference coatings, in electrochromic switching devices, and in shadow casting for electron microscopy.

- Tungsten Metal Powder (W Powder): Tungsten oxides are reduced using hydrogen to derive tungsten metal powder. Tungsten metal powder is a very versatile intermediate that is used in the production of ferrotungsten, superalloys, and mill products. Nonetheless, the largest utilization of tungsten metal powder is in tungsten carbide powder for use in cemented carbides.

- Tungsten Carbide Powder (WC powder): Most conventional tungsten carbide powder utilized in cemented carbide production is made from the carburization of tungsten powder (i.e. the thermal reaction of powder with high purity carbon). Tungsten carbide powder is used for making cemented carbide.

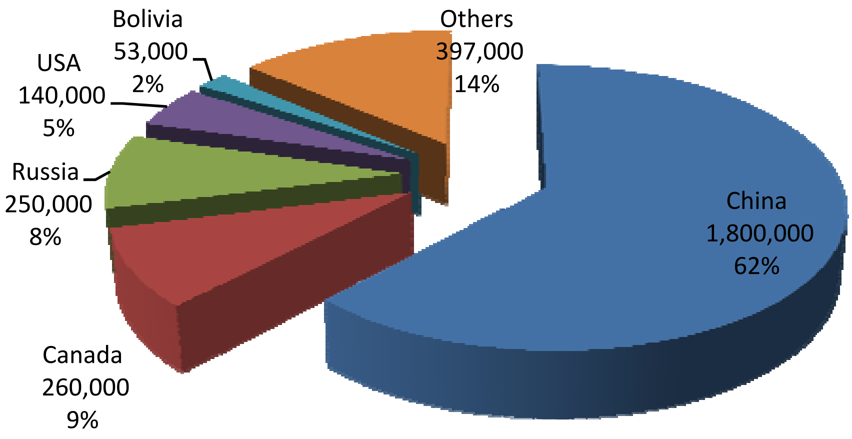
- Cemented Carbides: The largest commercial use for tungsten is in the form of tungsten carbide used in cemented carbides, a range of very hard, refractory, wear-resistant alloys. Cemented carbides are used in a variety of wear part applications, ranging from the very small, such as the balls for ball-point pens, to the large and heavy, such as punches, dies, or hot rolls for steel rolling mills. Fine and ultra-fine grained WC hard metals have become popular for use in wear parts, tools for chipless forming, and cutting tools for cast iron, non-ferrous alloys, and wood.

3. Global Tungsten Supply Analysis

3.1. Global Tungsten Reserves

The global proven tungsten reserves are only 2.9 million tons of metal contained, which gives this type of rare metal less than 50 years of usage with the current extraction rate. China hosts the world largest tungsten mineral reserves with 1.8 million tons of metal contained, accounting for 62.1% of the world total. Canada, Russia and the US also have tungsten reserves, accounting for 9.0%, 8.6% and 4.8% of world reserves, respectively.

Figure I- 2: Distribution of world tungsten reserves (tons of metal contained)



Source: CICC Research Dept.

3.2. Global Tungsten Production

As per International Tungsten Industry Association ("ITIA"), world tungsten production increased by 33.8% from 57,470 tons of metal contained in 2006 to 76,920 tons in 2010. This was primarily due to increase in production from China whose output grew from 44,000 tons in 2006 to 67,000 tons in 2010, even as supply from the rest of the world declined over that period. However, it should be noted that Asia Metal and USGS estimate China's 2010 production levels to be much lower at around 52,000 tons, which would imply that global production in 2010 was around 62,000 tons.

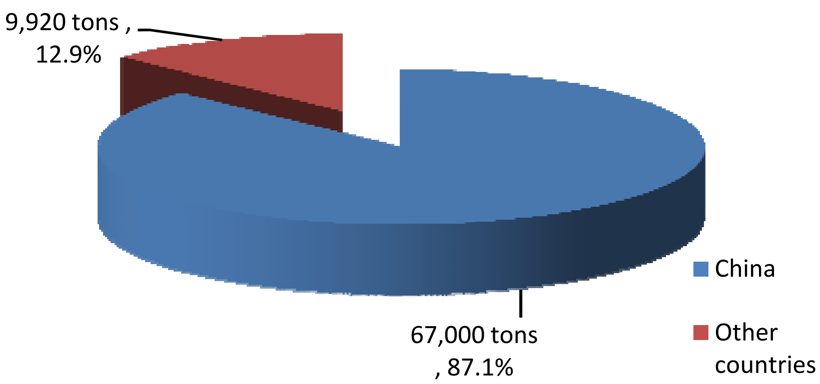
Table I- 2: World tungsten apparent mine production, 2006 – 2010 (tons of metal contained)

	2006	2007	2008	2009	2010
Africa	1,820	2,595	2,015	1,200	790
Austria	1,150	1,250	1,120	900	975
Bolivia	960	1,145	1,190	1,000	1,190
Brazil	90	340	280	300	250
Canada	2,030	2,355	2,280	1,960	420
Kazakhstan	-	150	-	25	25
Mongolia	90	200	145	140	185
Myanmar	-	-	35	95	-
Peru	50	410	400	465	560
Portugal	1,070	850	980	830	800
Spain	-	-	145	210	230
Thailand	290	445	855	200	270
Vietnam	-	-	-	725	1,150
Other sources	1,990	585	365	125	165
Sub Total	**9,540**	**10,325**	**9,810**	**8,175**	**7,010**
China's Production	44,000	41,000	51,500	55,500	67,000
Russia's Production	3,000	3,000	3,100	2,250	2,800
Korea DPR - Exports of concentrates to China	930	225	270	95	110
Total	**57,470**	**54,550**	**64,680**	**66,020**	**76,920**

Source: ITIA

As per ITIA estimates, in 2010, China accounted for approximately 87.1% of world tungsten production. The remaining production capacity primarily came from Russia, Bolivia, Vietnam and Austria.

Figure I- 3: Tungsten apparent mine production of China vs. other countries in 2010 (tons of metal contained)

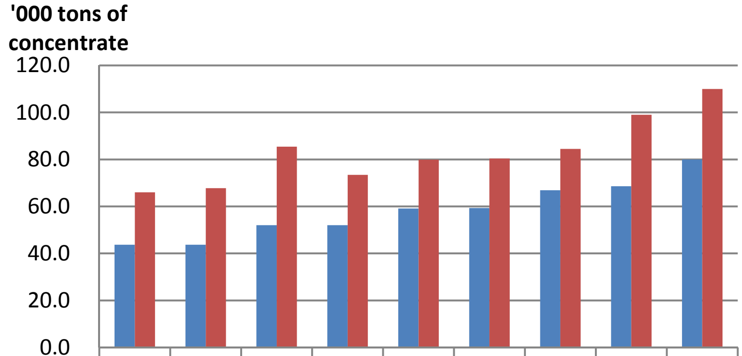


Source: ITIA

3.3. China’s Tungsten Supply

In 2010, according to Asia Metal, China produced about 110,000 tons of concentrate, which was 11% more than in 2009. In 2002, the Chinese authorities imposed an annually adjusted production cap on tungsten concentrate output, given tungsten’s status as a member of the strategic materials group. However, the real output has never been correspondingly controlled and, on average, a 40% overproduction was recorded each year. This is mainly due to the fact that China’s tungsten industry is widespread where indiscriminate mining activities are common.

Figure I- 4: China's tungsten concentrate production cap vs. real output (‘000 tons of concentrate)

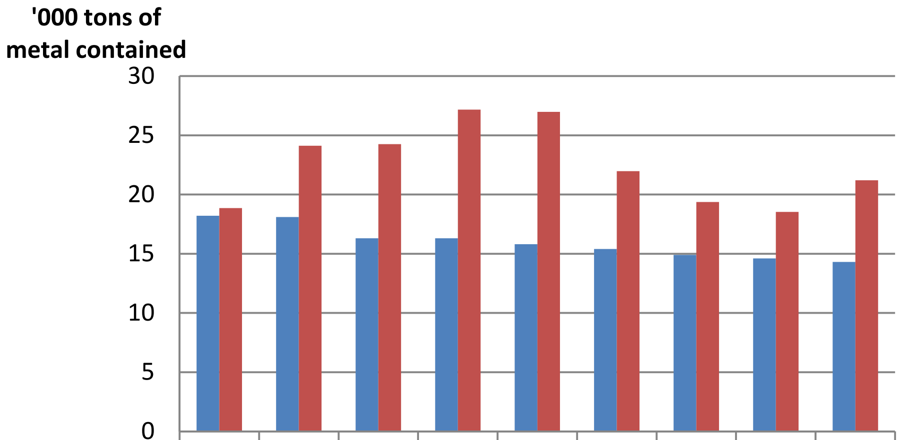


	2002	2003	2004	2005	2006	2007	2008	2009	2010
Production Cap	43.7	43.7	52.0	52.0	59.1	59.3	66.9	68.6	80.0
Real output	66.0	67.8	85.4	73.4	79.9	80.4	84.5	99.0	110.0

Source: Asia Metal

Despite having imposed a production cap over tungsten concentrate to control the market from the upstream, China also has a quota system for restricting the export of tungsten products. In 2010, the real export volume was 21,200 tons of metal contained, down about 21.8% compared to 2005, when China eliminated the export VAT rebate for tungsten concentrate and imposed a number of unfavorable tax policies over primary product exports. However, in 2010, the real export volume was still about 48.3% greater than the quota figure.

Figure I- 5: China tungsten products export quota vs. actual export
('000 tons of metal contained)



	2002	2003	2004	2005	2006	2007	2008	2009	2010
Export quota	18.2	18.1	16.3	16.3	15.8	15.4	14.9	14.6	14.3
Actual export	18.8	24.1	24.2	27.1	26.9	21.9	19.3	18.5	21.2

Source: Asia Metal

3.4. Major Tungsten Producers

3.4.1. Major Chinese Producers

a) Xiamen Tungsten Co., Ltd. (Listed on the Shanghai Stock Exchange)

- Production capacity: 14,000 t/y including 2,000 tons of cemented carbides; current production utilization is 60-100% (100% for APT, 60% for cemented carbide);

- Tungsten resources: 590,000 tons of metal contained as of July 2010; forecast concentrate production of 5,250, 5,775 and 6,641 tons of concentrate in 2010, 2011 and 2012, respectively; targeting an increase in its concentrate self-sufficiency rate from a current rate of 37% to a rate of 50% in the long-term.

b) Chongyi Zhangyuan Tungsten Co., Ltd. (Listed on the Shenzhen Stock Exchange)

- Production capacity: 10,000 t/y APT, 5,000 t/y tungsten powder, 4,000 t/y tungsten carbide, 1,500 t/y cemented carbide; current production utilization is between 60-95%.

- Tungsten resources: 4.9 million tons of ore containing 96,000 tons of WO_3 at 2.1% as of 2009; concentrate production of 3,578 tons in 2009.

c) Hunan Nonferrous Metals Holding Group Co., Ltd. (State Owned Enterprise)

Hunan Nonferrous Metals Holding Group is a group of companies that includes the following major tungsten producing enterprises:

- Hunan Shizhuyuan Nonferrous Metals Co., Ltd.: Resources of 747,000 tons of tungsten metal contained as of 2011.

- Zhuzhou Cemented Carbide Group Co., Ltd.: 6,000 t/y cemented carbide production capacity.

- Zigong Cemented Carbide Co., Ltd.: 4,000 t/y cemented carbide production capacity.

- Zhuzhou Changjiang Cemented Carbide Co., Ltd.: 1,000 t/y cemented carbide production capacity.

d) Jiangxi Tungsten Industry Group Co., Ltd. (State Owned Enterprise)

- Production capacity: 22,000 t/y for APT, tungsten powder and tungsten carbide powder.

- Tungsten resources: Exploitable reserves of wolframite metals account for 60% of China's total wolframite identified reserves; production capacity of 13,000 t/y for wolframite and scheelite concentrate.

3.4.2. Major Producers Outside China

At present, around 10 overseas tungsten mines are operating with limited production capacity.

a) North American Tungsten Corp., Ltd.

- Cantung mine (Canada): Indicated mineral resources of 2.6 million tons of ore at1.1% WO_3 as of October 2010, with 400,000 t/y of ore production.

b) WBH Wolfram Bergbau und Hütten GmbH.

- Mittersill (Austria): Proven resources of 6.1 million tons of ore, containing 30,500 tons of WO_3 at0.5% as of January 2001; 360,000 tons of ore production per annum.

c) Malaga, Inc.

- Pasto Bueno (Peru): Proven and probable reserves of 98,448 tons of ore at 0.95% WO_3, measured resources of 35,646 tons of ore grading 1.28% WO_3, indicated resources of 106,844 tons of ore grading 0.98% WO_3 and inferred resources of 1.2 million tons of ore grading 0.82% WO_3 as of March 2009; total production of 366 and 456 tons of metal contained in 2007 and 2008, respectively.

d) Heemskirk Consolidated

- Los Santos project (Spain): Proven and probable reserves of 2.6 million tons of ore at 0.3% WO_3 and inferred resources within the open pit of 745,000 tons of ore at 0.24% WO_3 as of June 2008; estimated 255 tons of metal contained produced per year.

e) Largo Resources

- Currais Novos project (Brazil): Indicated resources of 3.5 million tons of ore at 0.12% WO_3 and inferred mineral resources of 810,000 tons of ore at 0.093% WO_3 as of 2011; targeting 1,040 tons of WO_3 production per year.

f) Sojitz Corporation

- Panasqueira mine (Portugal): Proven and probable reserves of 2.4 million tons of ore at 0.243% WO_3 and indicated resources of 5.1 million tons of ore as of June 2009; estimated production of 850 to 1,000 tons of tungsten in concentrate per year.

g) Projects in production in Russia

- JSC A & IR Mining: Estimated production of 2,500 tons of WO_3 per year.
- ZAO Novo-Orlovsky: Estimated production of 600 tons of WO_3 per year.
- Quartz Artel: Estimated production of 600 tons of WO_3 per year.

3.5. Secondary Consumption

For tungsten processors, tungsten scrap provides an important additional source of raw material. Tungsten scrap is a high value material because its tungsten content is higher than tungsten ores or concentrate.

Information on the volume of recycled tungsten is very imprecise due to variances across products, regions and individual processors, and a lack of reliable data on production and trade. Usually, around 25-35% of global tungsten consumption is assumed to be accounted for by scrap, but for certain products, such as cemented carbides, and for many Western intermediate producers, this figure will be much higher. The ITIA estimates Chinese scrap consumption at 30% of total consumption in 2006. The CTIA estimates that the country’s scrap consumption accounted for 21.4% of apparent consumption in 2007. While the exact magnitude of China’s scrap consumption is unknown, it is clearly lower than in more developed economies.

3.6. Expected Changes in Supply

Globally, new additions of primary production outside China may be limited in the next two years due to:

- Difficulties faced by companies in financing new tungsten mines,

- Declining grades of new projects, and
- Increased development and operating costs.

The followings are the potential new mining projects that may come online in the near future:

a) Masan Resources – Nui Phao project (Vietnam)

- Resources: 55.4 million tons proven and probable reserves at 0.21% WO_3 as of July 2011.
- Project status: The Feasibility Study of the project has been completed and the company has raised financing to build the project. The company is currently undertaking construction of the project with production slated to begin in early 2013.

b) Woulfe Mining – Sangdong project (South Korea)

- Resources: 5.9 million tons indicated resources at 0.42% WO_3 as of May 2011.
- Project status: The Company is focused on completing the Pre-Feasibility Study and updating the current NI 43-101 resource estimate. Earthworks are slated to commence in December of 2011.

c) Wolf Minerals – Hemerdon project (UK)

- Resources: 70.9 million tons of measured and indicated resources at 0.18% WO_3 as of June 2010.
- Project status: Wolf commenced a Definitive Feasibility Study, and is currently reviewing and updating the archaeological and ecological baseline study to implement the planning permission.

d) North American Tungsten Corp., Ltd. – Mactung mine (Canada)

- Resources: Estimated 33 million tons of indicated resources at 0.88% WO_3 as of February 2009.
- Project status: The Company has completed Feasibility Study, and is forecasting to run at 2,000 tons of ore per day.

e) King Island Scheelite Limited "KIS" – Dolphin project (Australia)

- Resources: 2.7 million tons of probable reserves at 1.04% WO_3 as of August 2011.

- Project status: KIS is focusing on redevelopment of the original scheelite mine on King Island, and is forecast to produce approximately 3,300 tons of WO_3 concentrate per annum.

f) Hazelwood Resources Limited – Cookes Creek Tungsten (Australia)

- Resources: 9.5 million tons of measured resources at 0.16% as of 2011.

- Project status: Definitive Feasibility Study is in progress. This project is treated as a future source of feedstock for its downstream ferrotungsten plant in Vietnam.

g) Vital Metals Ltd. – Watershed project (Australia)

- Resources: 15.1 million tons measured resources at 0.46% as of 2004.

- Project status: Draft Pre-Feasibility Study was completed in late 2008.

h) Venture Mineral – Mt Lindsay Tin-Tungsten Project (Australia)

- Resources: 43 million tons indicated and inferred resources at 0.1% WO_3 as of 2011.

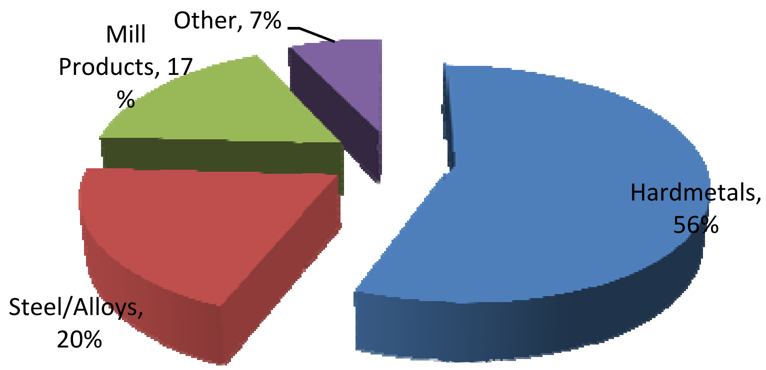
- Project status: Pre-Feasibility Study was completed in March 2011.

4. Global Tungsten Demand Analysis

4.1. Tungsten Demand by Product

Tungsten is consumed in a variety of diverse commercial, industrial and military applications. The accompanying chart shows CRU's estimates of global demand for primary tungsten by end-use sector in 2007. The consumption of tungsten is dominated by "hard metals" or cemented carbides, which are used in high performance drills and cutting tools. The second most important end-use sector is steel manufacturing, more specifically tool steels and high speed and strength steels. Mill products represent the third most important end-use sector for worldwide primary tungsten demand, with a share of 17% in 2007. The remainder of primary tungsten demand comes from other end-use sectors, primarily chemicals.

Figure I- 6: Global primary tungsten demand by end-use sector in 2007:



Source: CRU Analysis

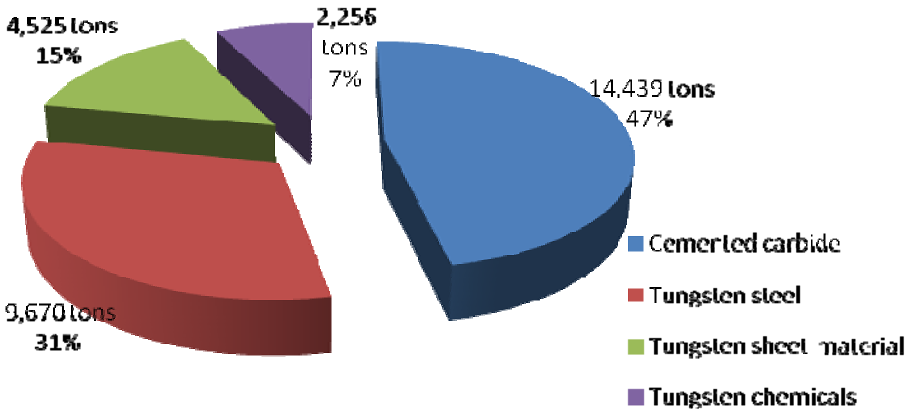
4.2. Tungsten Demand by Region

4.2.1. China's demand

In China, about 60-90% of primary products, including concentrate, APT and tungsten oxide, are usually consumed by major manufacturers themselves for internal consumption or further processing; only 10-40% is sold to other tungsten product manufacturers or industry giants with export licenses, such as China Minmetals. The buyers of concentrate and APT are usually tungsten product manufacturers with the capacity to process concentrate and APT into mid- and down-stream products. The major buyers include Xiamen Tungsten, Chongyi Zhangyuan Tungsten, Hunan Nonferrous Metals Holding Group, Jiangxi Tungsten Industry Group, Ganxian Qihui Tungsten Co., Xiamen Chunbao Tungsten and Bingzhou Zuanshi Tungsten. The major exporter is China Minmetals.

In 2010, China consumed more than 30,890 tons of tungsten metal contained, which was 14.5% more than in 2009. Approximately 47% of China's tungsten consumption was used to manufacture cemented carbide and 31% for tungsten steel. The remaining 22% was used in tungsten sheet material and tungsten chemicals.

Figure I- 7: China's tungsten consumption structure in 2010 (tons of metal contained)

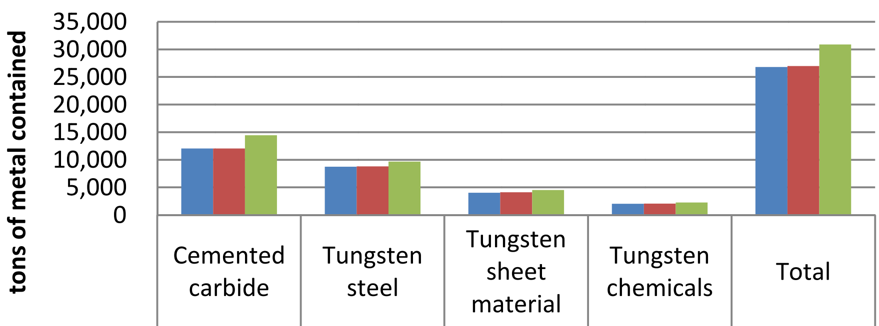


Source: China Tungsten Industry Association

The quantity of tungsten China consumed in 2010, by product type, was as follows:

- Cemented carbide: 14,439 tons of metal contained consumed in 2010, 20% more than in 2009.
- Tungsten steel: 9,670 tons of metal contained consumed in 2010, 10% more than in 2009. At present, China is the largest steel producer in the world, with total production of 567 million tons in 2009, or approximately 46% of total world production. For the last 10 years, China's steel production has grown at an average annual rate of 21%.
- Tungsten sheet material: 4,525 tons of metal contained consumed in 2010, 10% more than in 2009.
- Tungsten chemicals: 2,256 tons of metal contained consumed in 2010, 10% more than in 2009.

Figure I- 8: China tungsten consumption by product, 2008 – 2010 (tons of metal contained)



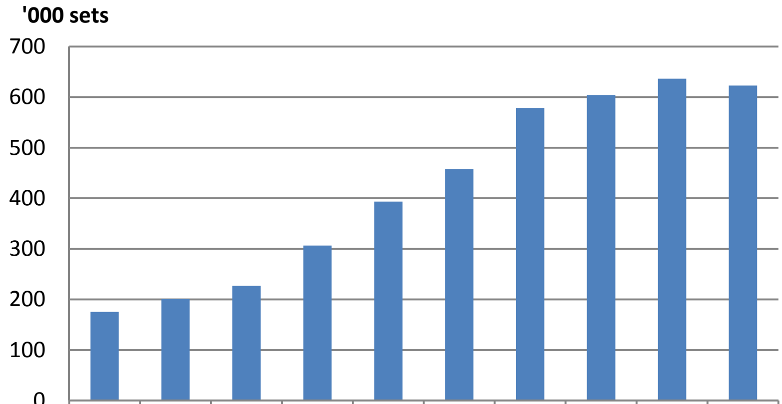
	Cemented carbide	Tungsten steel	Tungsten sheet material	Tungsten chemicals	Total
2008	12,031	8,734	4,033	2,020	26,818
2009	12,033	8,791	4,114	2,051	26,989
2010	14,439	9,670	4,525	2,256	30,890

Source: China Tungsten Industry Association

Approximately 58% of cemented carbide is used to manufacture cutting and mining instruments, which are the key components of metal cutting machines, numerical machines and mechanical engineering equipment.

Statistics from Wind and CICC indicate that China's metal cutting machine and numerical machine industries have developed rapidly, with compound annual growth rates of 16% and 30%, respectively, from 2000 to 2009. The mechanical engineering equipment industry has also seen rapid growth, with a compound annual growth rate of 29% from 2003 to 2009. According to market research, China's machine and mechanical equipment market is forecasted to maintain an annual growth rate of 30% for the next 5 years given the strong demand for numerical machines in the aerospace industry and mini excavators in the mining industry.

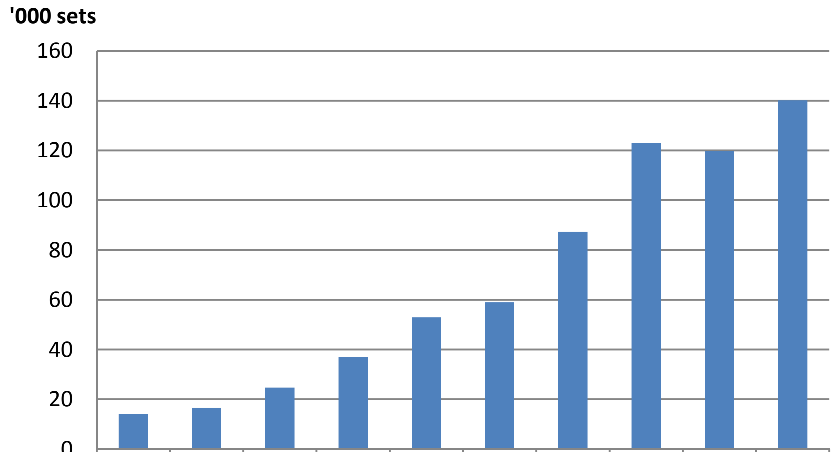
Figure I- 9: Production of metal cutting machine instruments in China, 2000 – 2009 ('000 sets)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
in '000 sets	175.3	200.8	227	306.6	393.5	457.8	578.8	604.2	636.4	622.8

Source: Wind, CICC

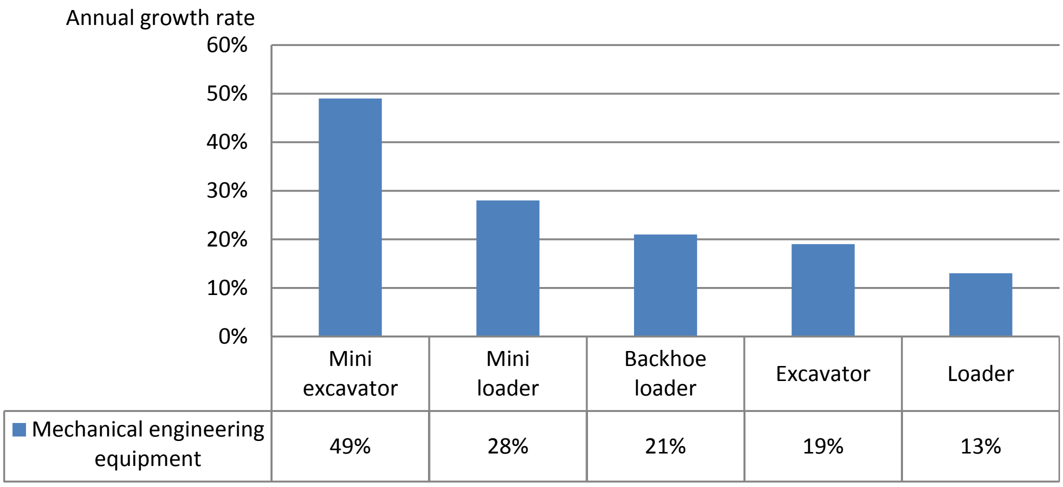
Figure I- 10: Production of numerical cutting metal machine instrument in China 2000-2009 ('000 sets)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
in '000 sets	14.1	16.6	24.7	36.9	52.9	59	87.3	123.1	119.8	140.1

Source: Wind, CICC

Figure I- 11: Compound annual growth rate of mechanical engineering equipment in China, 2003 – 2009:



Source: Wind, CICC

4.2.2. Demand Outside China

From 2006 to 2010, the global demand of tungsten (excluding China) contracted modestly at a compound annual rate of approximately 5.8%. The total demand for tungsten in 2010 was reduced to approximately 31,600 tons metal contained, which was approximately 20% lower than in 2006.

Table I- 3: Historical demand of tungsten by region (excluding China), 2006 – 2010 (tons of metal contained)

	2006	2007	2008	2009	2010
US	10,200	8,400	9,250	7,100	9,300
Europe	16,650	13,850	12,050	5,850	8,800
Japan	7,900	6,850	7,750	2,500	7,350
Rest of the world	4,950	6,700	4,350	2,200	6,150
Total	**39,700**	**35,800**	**33,400**	**17,650**	**31,600**

Source: ITIA

a) The US

Based on ITIA's data, demand for tungsten in the US fluctuated from 2006 to 2010. In 2010, the demand recovered significantly by 30.9% from the previous year; however, it was still about 8.8% lower than the 2006 figure.

b) Europe

Europe is an important global consumer of tungsten, though consumption has been decreasing over the last five years. ITIA estimated Europe's demand to be 16,650 tons metal contained in 2006, while the demand in 2010 was reduced to 8,800 tons metal contained. The demand in 2010 was 52.8% lower than in 2006, although it had recovered more than 50% from 2009.

c) Japan

In 2010, Japan's demand recovered significantly, reaching 7,350 tons metal contained compared to 2,500 tons in 2009; however, 2010 demand was still approximately 7% lower than 2006.

d) Rest of the world

After the fall of the Soviet Union in 1991, the consumption and production of tungsten in Russia fell sharply as a result of the closure of many tungsten mine producers and processors and the broader contraction in industrial output. The ITIA does not estimate annual tungsten demand in Russia, but puts its domestic consumption in the region of 3,000-4,000 tons metal contained per annum, including scrap.

Among Asian countries (excluding Japan and China), South Korea is a notable consumer of tungsten. South Korea has large automotive, electronics, shipbuilding and steel industries that use tungsten, and is investing heavily in new power generation capacity. A large industrial consumer of tungsten in the country is Taegu Tec, a producer of tungsten carbide cutting tools, tungsten powders, tungsten carbide rolls and industrial products. Taegu Tec has been seeking to expand its share of the global market by developing new products and expanding its production and geographical presence.

Demand for tungsten in India is increasing gradually through its imports of carbides. This is partially thanks to some foreign cutting tools producers, including Sandvik, Taegu Tec and Kennametal, which are investing in export-oriented manufacturing facilities in the country.

CRU estimated that exports of metal oxides, including tungsten oxides, to Israel (where Iscar, one of the world's largest tungsten cutting tool manufacturers, is located) by other countries totaled around 2,268 tons in 2007.

4.2.3. Demand drivers

The main driver of growth for tungsten markets is the level of industrial output, especially the rate of machine tool capital spending related to automotive production, aerospace industries, drilling in the mining and energy sectors, and military spending. For example, China's tungsten consumption had a CAGR of approximately 10% per annum from 2001 to 2009. This was mainly driven by China's increasing industrial output, in particular the robust demand for metal cutting machines and numerical instruments, which enjoyed a CAGR of approximately 16% and 30%, respectively, during the same period. Some previous spikes in tungsten demand can be attributed to high levels of military spending during periods such as the Korean War. While there may be some potential for increased demand for tungsten as it replaces lead in so-called "green ammunition", this is not expected to be a large growth area and spending has actually decreased in the United States, where resources have been diverted elsewhere. The use of tungsten for incandescent lighting is expected to decline in the longer term as countries and US states ban or encourage reductions in the use of incandescent light bulbs. However, this is not expected to materially impact overall tungsten demand since tungsten is also used to a lesser extent in fluorescent light bulbs and the size of the lighting market is relatively small, accounting for less than 3% of total demand. Near total replacement of incandescent bulbs will be a slow process on a worldwide basis taking many years to fulfill, and, as mentioned, some tungsten will also be used in the replacement lighting.

5. China Dynamics

5.1. China's Demand and Supply Balance

In 2010, though constrained by total production control, an export quota and energy-saving policies, China's tungsten production still increased by 11.8% as compared to 2009. Meanwhile, tungsten consumption increased by 14.5% due to strong demand from end-use sectors, especially for cemented carbides. Overall, total supply and demand remained balanced. The table below shows China's supply and demand balance for 2008-2010:

Table I- 4: China's tungsten supply and demand balance, 2008 – 2010 ('000 tons of metal contained)

'000 tons of metal contained	2008	2009	2010
Production (P)	44	51	57
Net of export/Import (E)	18	8	18
Consumption (C)	27	27	31
Balance (P-E-C)	-1	16	8

Source: Beijing Antaike Information Tech

For the next couple of years, it is expected that the balance of tungsten supply and demand in China will remain relatively stable. However, the tungsten market may be subject to the influence of unpredictable factors such as Chinese Yuan appreciation, taxes, a change in the degree of industry consolidation or new environmental protection policies.

5.2. China's Policies

China's government treats tungsten as a member of the strategic materials group, protecting its scarce resources through steps that include a total production cap, an export quota, tax policies and industry consolidation.

- Total production cap:

In 2002, the Chinese authorities imposed an annually adjusted production cap over tungsten concentrate output due to its status as a member of the strategic materials group. The total production cap in 2010 is 80,000 tons of concentrate, compared to 44,000 tons in 2002.

- Export quota:

China has a quota system for restricting the export of tungsten products. The export quota for tungsten products in 2010 was 14,300 tons of metal contained. The quota has been reduced steadily at an average annual rate of 3.1% since 2002, when it was 18,200 tons of metal contained.

- Export tax policies:

In 2004, Chinese authorities eliminated the 13% export VAT rebate for tungsten concentrate and tungsten scrap.

In May 2005, the export VAT rebate for tungsten oxide, APT, tungsten carbide, unwrought tungsten, and other tungsten products was reduced from 13% to 8%; it, too, was then completely removed in September 2006.

In January 2007, a provisional export tax rate of 5-10% was imposed on primary tungsten products.

In July 2007, the export VAT rebate for mixtures of cemented carbide was also removed.

On the other hand, to promote exports of downstream products, the export VAT rebate for carbide cutting and drilling tools was increased from 5% to 11% in November 2008, and again, to 14%, in December 2008, and yet again, to 15% in June 2009.

- Other applicable taxes for tungsten manufacturers in China

Table I- 5: Other applicable taxes

Tax	Tax basis	Tax rate
VAT	Value added of goods in sales process	17%
Urban maintenance & construction tax	VAT payable	5%
Education surcharge	VAT payable	3%
Local education surcharge	VAT payable	1-2%
Export tax	Sales of primary products	5%
Corporate income tax	Taxable income	25% or 15%
Resource tax	Ore production	RMB 8/ton
Mineral resources compensation	Mineral product sales	2%

- Industry consolidation in China:

Since 2009, China Minmetals Corporation (a SOE) has been very active in consolidating China's tungsten industry by acquiring controlling stakes in Hunan Non-Ferrous Metal Holding Group Co., Ltd. (HNG) and other tungsten businesses in the Jiangxi province. The industry giant now controls more than 50% of the tungsten resources in China, accounting for around 35% of the world total. The followings are the major transactions that have taken place in China in recent years:

a) China Minmetals Non-Ferrous Metal Co., Ltd. (CMN) acquired a controlling stake in Hunan Non-Ferrous Metal Holding Group Co., Ltd. (HNG).

b) CMN's tungsten-related consolidation in Jiangxi and other provinces: CMN acquired control over a number of other tungsten-related businesses in Jiangxi Province, such as Jiangxi Tungsten Industry Group Co., Ltd., Nanchang Cemented Carbide Ltd., and Jiangxi Xiushuixianglu Scheelite Mine. China Minmentals Corporation also holds a 20.6% stake in Xiamen Tungsten Co., Ltd. the largest tungsten smelter in China.

c) Aluminum Corporation of China (Chinalco)'s tungsten-related consolidation in Jiangxi province: In March 2010, the Jiangxi Provincial Government and Chinalco entered into a framework agreement for strategic cooperation. The pilot cooperation is based on the platform of Jiangxi Rare Earth and Rare Metal Tungsten Group Holding Co., Ltd. and its affiliated subsidiaries. Chinalco is set to eventually obtain a controlling stake in the holding company.

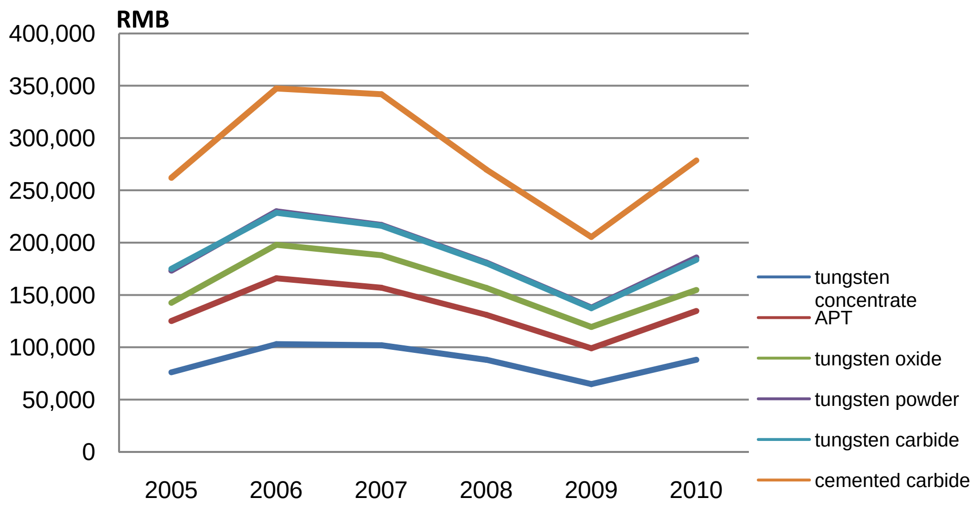
d) China Metallurgical Group Corporation (MCC)'s presence in the tungsten industry: MCC also has its own tungsten-antimony operation in the Hunan province; the project is operated by its wholly owned subsidiary, MCC Huaye Resources Development Company.

Chinese companies have also showed interest in securing overseas tungsten mine assets. In January 2011, HNG acquired 7.1% of King Island Scheelite Limited "KIS", which owns the Dolphin tungsten project in Australia.

6. Pricing

In 2005, China's domestic price for tungsten concentrate (65% WO_3) reached a peak at RMB 130,000 per ton of concentrate. The price fell to a low of RMB 50,000 per ton of concentrate in January 2009. Since then, the price has steadily increased and concentrate was trading near the peak level of RMB 130,000 per ton in March 2011.

Figure I- 12: Prices of China's tungsten products



Source: CICC report, Xiamen Tungsten Co., and Chongyi Zhangyuan Tungsten Co.

Based on data from ITIA, global supply and demand remained balanced from 2005 to 2010. Tungsten demand from developed economies such as Europe, the US and Japan has slowed since 2006; tungsten price, therefore, was mainly driven by the demand from emerging markets. There is a general consensus that the price of tungsten is expected to remain high for the foreseeable future due to both demand fundamentals and the following China factors:

- The scarcity and importance of tungsten resources: It is estimated that tungsten resources in China will be exhausted within 15 to 20 years at current production rates.

- Tungsten's status as a strategic material: China treats tungsten as a member of the strategic materials group, and efforts have been taken by the government to protect the scarce resources.

- Tightened supply control by Chinese authorities: Policies have been implemented to control total production output and export volume.

- Adjustment of export tax policies: In 2006, the export tax rebate for primary products was completely removed, and an export tax of 5%-10% was imposed. These adjustment of export tax policies have increased the cost and prices of exported products.

- Active industry consolidation: Since 2009, China industry giants such as CMN, Chinalco and MCC have been very active in acquiring tungsten businesses in the Jiangxi, Hunan, and other provinces in China. China Minmetals Corporation now controls more than 50% of the tungsten resources in China, accounting for around 35% of the world total.

Part II: Fluorite

1. Introduction to Fluorite and Properties

1.1. Properties of Fluorite

Fluorite, for which the commercial name is fluorspar, is a halide mineral composed of calcium fluoride (CaF_2), which theoretically contains 51.3% calcium and 48.7% fluorine. Fluorite has a low melting point and imparts greater fluidity at low temperatures when added to metallurgical slag. This nature makes fluorite valuable as a flux in smelting. It is also the principle industrial source of the element fluorine and is commonly used in making fluorine-contained chemicals such as hydrofluoric acid.

1.2. Occurrence

Fluorite occurs in a wide variety of geological environments. Virtually all mined fluorite must be upgraded and the beneficiation techniques selected need to be tailored to the character of the ores and the end-use specifications. For instance, where low-cost labor is available, metallurgical-grade fluorite may be produced by hand sorting high-grade lump crude ore, then crushing and screening it to remove most of the minus 10-mesh fraction. In some cases, very high-grade fluorite ores can be shipped directly after the screening process. In the case of lower-grade ores and/or ores with relatively coarse interlocking minerals, gravity processes of concentration are used based on the specific gravity of 3.2 for fluorite and less than 2.8 for most gangue minerals. Acid grade concentrates are produced by froth flotation process after the run-of-mine ore is crushed and ground to a size that liberates the individual minerals, enabling their separation.

1.3. Fluorite Grades and Uses

There are three principal market grades of purity, corresponding to different industrial uses of natural fluorite, although the specific requirements set by individual consumers may vary.

- Acid grade fluorite (97% or more CaF_2): is the primary industrial source of fluorine. Acid grade fluorite is used for making hydrogen fluoride (HF) and hydrofluoric acid. It is an important raw material for most fluorine-containing fine chemicals, including fluorocarbons, aluminum fluoride, and synthetic cryolite.

- Ceramic (intermediate) grade fluorite (85-95% CaF_2): is used in the manufacture of opalescent glass, enamels and cooking utensils.

- Metallurgical grade fluorite (60-85% CaF_2): is used as a flux to lower the melting point of raw materials in steel production to aid the removal of impurities.

Table II- 1: Fluorite category by calcium fluoride content

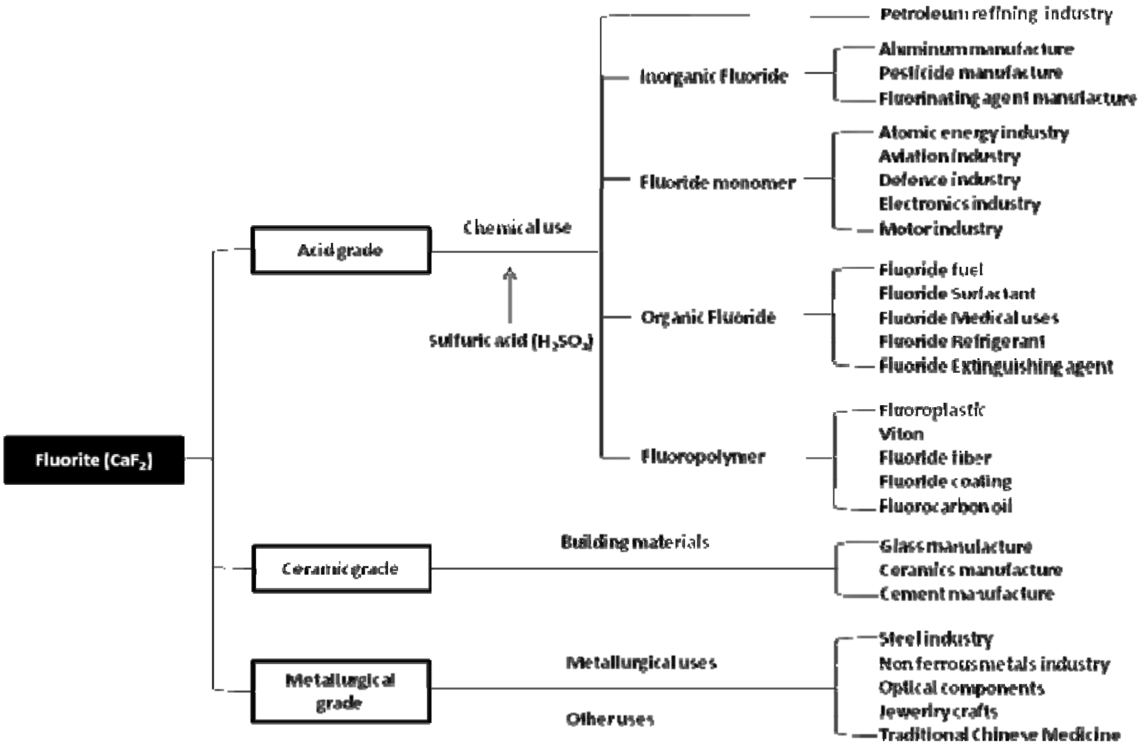
Category	Calcium fluoride content
Acid grade fluorite	97% or more
Ceramic grade fluorite	85% - 95%
Metallurgical grade fluorite	65% - 85%

Rarer, optically clear transparent fluorite is useful for optics. Transparent fluorite has low dispersion, so lenses made from it exhibit low chromatic aberration, a useful quality for microscopes and telescopes. Fluorite lenses can also be used in the far-ultraviolet range where conventional glasses are too absorbent for use. Fluorite may also be drilled into beads and used in jewelry, although, due to its relative softness, it is not widely used as a semiprecious stone.

2. Value Chain of the Fluorite Industry

The three main grades of fluorite – acid, ceramic and metallurgical – are each designated for a given set of uses. In general, acid grade fluorite is used to make hydrofluoric acid, which is used as an intermediate for the manufacture of a range of fluorine-based chemicals, including fluorocarbons, aluminum fluoride, and synthetic cryolite. Ceramic-grade fluorite is used in ceramics, glass, and sundry other uses. Metallurgical-grade fluorite is used as a flux in steel manufacturing, in iron foundry and ferroalloy practice, and has many minor specialized uses.

Figure II- 1: Fluorite applications



Source: Somerley, Zhejiang Provincial Department of Land Resources

2.1. Chemical Industry

Fluorine-containing fine chemicals are basic materials for a range of products across various industries. Hydrofluoric acid is the starting point for an assortment of fluorine-based chemicals. More than half of the global fluorite output is used for acid production, and the trend is towards an increase in both the amount and the proportion of fluorite resources that are being put to this use.

Hydrofluoric acid can be used to synthesize chemicals such as aluminum fluoride (AlF_3), synthetic cryolite, sodium fluoride and magnesium fluoride. Its wide set of applications also include uses in the petro-chemical industry, semiconductor manufacture, pesticides, preservatives, protectants, additives, fluxes and antioxidants.

Aluminum manufacture represents an important segment of the fluoride chemical market. The growth of this market is supported by increasing demand for aluminum in the automotive industry, but counterbalanced by improvements in smelting technology, increased recycling of both aluminum and fluorine, and increased use of AlF_3 derived from fluorosilicic acid.

Hydrofluoric acid is also used to produce a range of organic compounds, particularly fluorinated alkanes (i.e. HFC – 134a), which are applied in industrial and domestic refrigeration systems as well as fluoropolymers. Demand for fluorite in the manufacture of fluoropolymers and fluoroelastomers is growing rapidly.

2.2. Building Materials Industry

Fluorite is widely used as an additive in the manufacture of building materials. The following table illustrates the various fluorite requirements for different applications:

Table II- 2: Applications in the manufacture of building materials

Industry	Application
Cement industry	Low-grade fluorite with CaF_2 content at 40% and relatively high impurity is commonly used.
Glass industry	As a flux and light screening agent, fluorite stimulates the melting process of raw materials and improves the quality of glass. In general, the glass industry sets a high standard for the fluorite input, requiring CaF_2>85%, Fe_2O_3<0.2%.
Ceramic industry	In ceramic manufacturing, fluorite is primarily used in glazing. Depending on the ceramic glaze, the proportion for fluorite input is 10%-20% and strict quality requirements are applied: CaF_2>95-96%, Fe_2O_3<0.1%, SiO_2<3.0%, $CaCO_3$<1.0%.
Cast stone industry	Fluorite is an ideal solvent for the cast stone melting process. A 0.3%-1.5% dosage helps adjust the composition of the cast stone, lower the melting temperature, and enhance fluidity. The required grade is CaF_2>85%.

Source: Changjiang Securities

2.3. Metallurgy Industry

It was discovered very early that fluorite can effectively lower the melting point of refractory minerals–hence its application as a flux in steel and non-ferrous metals manufacturing. Usually 6-9kg of fluorite is consumed per ton of iron, and 2-9kg per ton of steel.

In recent years, the industry has recorded a fall in usage of fluorite as a flux, mainly for the following reasons:

1. Fluorite causes chemical corrosion to the lining of the furnace, cutting short the years of usage;
2. Tightening environmental policy has restricted the permissible levels of fluoride pollution;
3. Effective substitutes such as dolomite and lime are becoming more commonly used; and
4. Relative shortages in fluorite resources and increasing prices have shifted consumption towards higher value added products.

3. Global Fluorite Supply Analysis

3.1. Global Fluorite Reserves

In 2010, the global fluorite recoverable reserves were reported at 230 million tons, with identified resources at around 500 million tons. South Africa, Mexico, China and Mongolia top the world in fluorite reserves, jointly hosting 47.4% of the world total fluorite recoverable reserves.

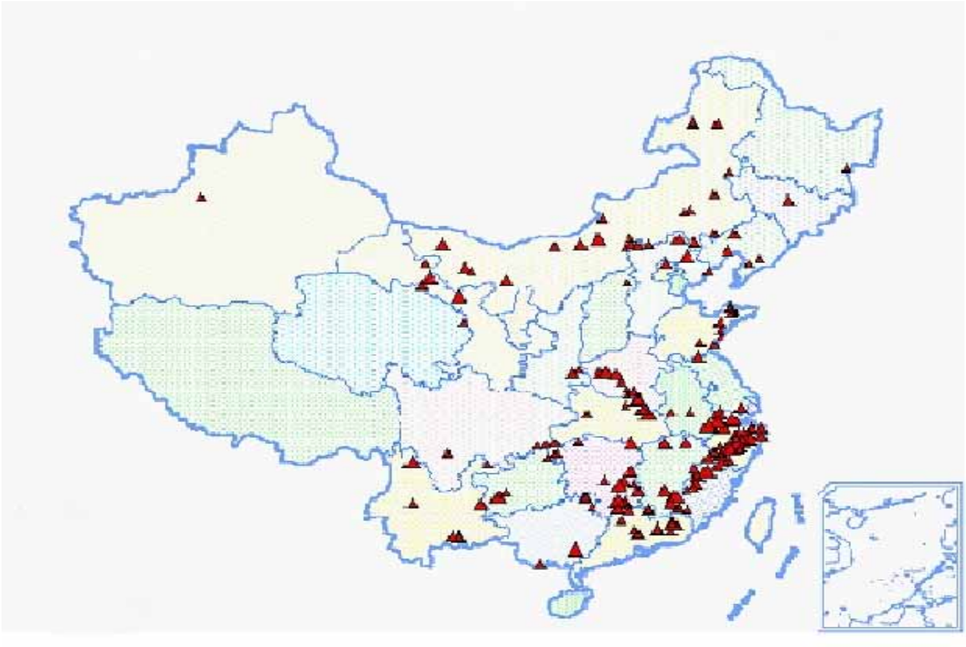
Table II- 3: World major fluorite resources countries in 2010

Country	Recoverable Reserves (in million tons)	Proportion
South Africa	41	17.8%
Mexico	32	13.9%
China	24	10.4%
Mongolia	12	5.2%
Spain	6	2.6%
Namibia	3	1.3%
Kenya	2	0.9%
Russia	n/a	n/a
The US	n/a	n/a
Morocco	n/a	n/a
Others	110	47.8%
Total	**230**	100.0%

Source: USGS

China, to date, has over 500 proven fluorite-contained ore zones, located in 27 provinces (municipalities and autonomous regions). China has the world's largest identified resources of fluorite at around 110 million tons, nearly a quarter of the world total. However, its recoverable reserves are only 24 million tons, representing 10.4% of the world total. Geographically, Hunan Province, Inner Mongolia and Zhejiang Province host 38.9%, 16.7% and 16.1% of China's fluorite resources, respectively. The remaining 27.8% is distributed in other regions of the country.

Figure II- 2: Sketch map of fluorite mineral resource distribution in China



The following table gives the top four fluorite deposits in China by their scale of the resources.

Table II- 4: China's major fluorite deposits

Major Deposit	Resource scale and grade
Hunan Shizhuyuan	45.9 million tons @ 21.7%
Inner Mongolia Sumoqagan Obo	10.3 million tons @ 53.9%
Hunan Taolin	6.1 million tons @ 14.3%
Zhejiang Hushan	4.5 million tons @ 50%

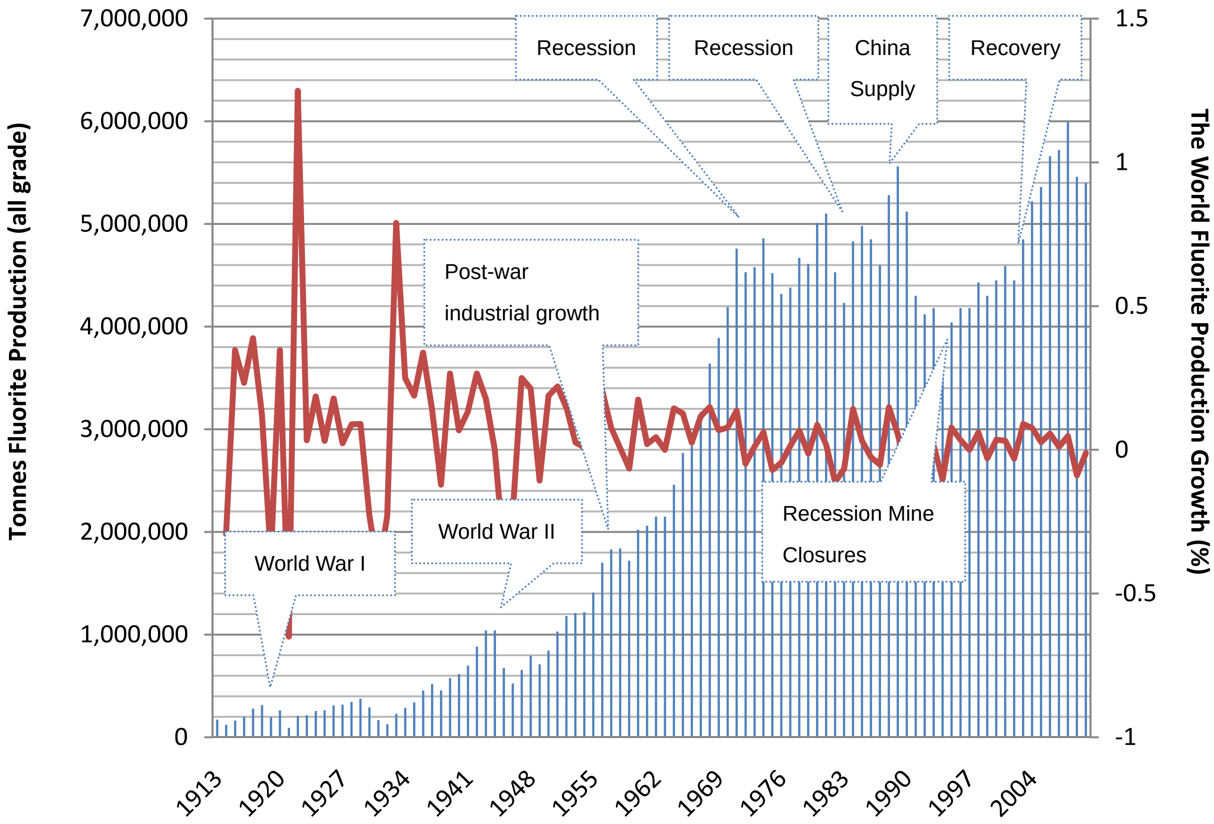
Source: Somerley

3.2. Global Fluorite Production

The US Geological Survey first reported world fluorite annual production at 171,000 tons in 1913. It increased from less than 200,000 tons during World War I to surpass 1 million tons for the first time during World War II. After a brief post-war decline, output exceeded 1 million tons once again during the 1950s and then increased steadily for another 3 decades. Output reached 5 million tons in 1981 and peaked at 5.6 million tons in 1989 ahead of the Montreal Protocol restrictions. Subsequently, output has fluctuated according to the state of the world economy and usage restrictions, with a sharp decline to a low of 3.8 million tons in 1994 as a result of low steel output and improved efficiencies. The rapid decrease in fluorite production that preceded this market low was also largely due to restrictions related to the Montreal Protocol on the use of fluorocarbons (particularly CFCs) in refrigerant gases, aerosol propellants and foam blowing agents.

Demand has subsequently improved, strengthening to 5.1 million in 2004, consistently equaling or exceeding 5 million tons thereafter, and reaching 6 million tons in 2008. This round of recovery is mainly due to the growing demand for acid grade fluorite across chemical industries.

Figure II- 3: World fluorite annual production, 1913 – 2009



Source: Somerley, USGS, Peter W. Harben Inc.

The following table provides a statistical summary of fluorite production by country for the period between 2005 and 2009. China, Mexico, Mongolia, South Africa and Russia are the world's top five fluorite-producing countries. In 2009, these five countries together produced 4.8 million tons, or 88.7% of the world total.

It is worth noting that fluorite output from China alone exceeds 53% of the world total. From 2006 onward, China's annual fluorite production has stayed at around 3 million tons. If this level of fluorite production continues and China fails to make significant new discoveries, China's recoverable reserves will be exhausted within 8 years.

Table II- 5: World fluorite production, 2005 – 2009 (in tons)

Country	2005			2006			2007			2008			2009		
	T	A	M	T	A	M	T	A	M	T	A	M	T	A	M
Argentina	7,502			8,278			9,735			15,098			15,000		
Brazil	66,512	42,043	24,469	63,604	41,373	22,231	65,451	44,869	20,582	64,356	45,342	19,014	64,059	44,559	19,500
China	2,800,000	1,650,000	1,150,000	3,100,000	1,800,000	1,300,000	3,200,000	1,850,000	1,350,000	3,250,000	1,900,000	1,350,000	2,900,000	1,600,000	1,300,000
Egypt	549			550			1,080			470			500		
France	90,000	80,000	10,000	40,000	35,000	5,000									
Germany	35,364	35,364		53,009	53,009		54,359	54,359		48,519	48,519		45,000	45,000	
India	10,900	4,400	6,500	5,300	500	5,800	6,000	1,000	5,000	7,000	15,000	5,500	7,200	1,600	5,600
Iran	64,601			65,000			68,192			65,000			65,000		
Italy	15,000			8,000											
Kazakhstan	4,750			30,000			64,000			66,300			67,000		
Kenya	97,261	97,261		83,428	83,428		82,000	82,000		98,248	98,248		15,667	15,667	
Kyrgyzstan	4,000			4,000			4,000			4,000			4,000		
Mexico	875,540	324,568	550,882	936,000	466,000	470,000	933,000	513,000	420,000	1,060,000	630,000	428,000	1,040,000	630,000	410,000
Mongolia	327,100	93,700	233,400	347,700	108,300	239,400	354,900	109,900	245,000	334,800	115,700	219,100	459,500	115,300	344,200
Morocco	114,740	114,740		94,254	94,254		78,900	78,900		60,700	60,700		75,000	75,000	
Namibia	105,700	105,700		121,700	121,700		109,300	109,300		108,800	108,800		73,580	73,580	
Pakistan	1,040		1,040	2,839		2,839	1,500		1,500	1,400		1,400	1,300		1,300
Romania	15,000		15,000	15,000		15,000	15,000		15,000	15,000		15,000	15,000		15,000
Russia	245,500			210,000			180,000			269,000			240,000		
South Africa	266,000	250,000	16,000	256,000	240,000	16,000	285,000	268,000	17,000	299,000	281,000	18,000	204,000	196,000	8,000
Spain	143,995	133,495		153,105	135,864		149,032	132,753		149,300	133,000		140,000	125,000	
Tajikistan	8,500			8,500			8,500			8,500			8,500		
Thailand	295		295	3,240		3,240	1,820		1,820	29,529		29,529	3,000		3,000
UK	56,417			49,676			44,936			36,801			18,536		
Grand Total	5,360,000			5,660,000			5,720,000			5,990,000			5,460,000		

T: Total; A: Acid Grade; M: Metallurgical Grade
Source: USGS

Comparing China's recoverable reserves to production ratio of less than 8 years to the world's ratio of around 40 years suggests that, in the near future, a geographic shift in fluorite production from China to the rest of the world may occur. This will be also supported by fundamental economic changes. In the past, fluorite producers in developing countries, especially China, benefited from low energy and labor costs and were encouraged to export raw materials such as fluorite. The historical advantages that contributed to making China such a dominant fluorite producer are gradually disappearing. Given the fact that a large proportion of the world's fluorite reserves are located outside of China (Table II- 3), and should relatively high fluorite prices prevail, we may expect the reopening of previously closed fluorspar mines and possibly the development of new mines in Africa, North America and Europe.

3.3. China's Fluorite Supply

China's more than 600 fluorite mines are spread over more than twenty provinces, with the majority located in the Zhejiang, Jiangxi and Hunan provinces. Most of these mines are very small with production of no more than 30,000 tons per year.

Table II- 6: Major fluorite producers in China

Company	Capacity	Remarks
China Kings Resources Group Co., Ltd.	Exploitation and beneficiation processing capacity of 800,000 t/y of fluorite ores and metal ores.	Over 25million tons of identified fluorite reserves; 13 exploration licenses; 4 fluorite mines in operation.
CFIC Industries Group	Producing all kinds of fluorite products 350,000 t/y and fluorite powder 200,000 t/y.	
Zhejiang Wuyi Shenlong Floatation Co., Ltd.	Producing acidic fluorite powder 140,000 t/y and various ore particles 180,000 t/y.	A comprehensive fluorite processing enterprise integrating exploitation, flotation and drying; three branch plants and two fluorite mines.
Zhejiang Minmetals Huaxing Import & Export Co., Ltd.	Production capacity of 200,000 t/y.	
Zhejiang Yiwu Mining Co., Ltd.	Production capacity of 100,000 t/y of fluorite.	
Zhejiang Jinhua Mining Co., Ltd.	Production capacity of 20,000 t/y of fluorite.	
Sanshan mining Co., Ltd.	Production capacity of 100,000 t/y of fluorite ores, 30,000 t/y of fluorite powder, and 20,000 t/y of ore particles.	Currently has four mines with 2 million tons in reserves and one concentration plant.
Jiangxi Huichang Shilei Minerals Co., Ltd.	Production capacity of 130,000 t/y of fluorite.	The major supplier to Minmetals; Minmetals exports 100,000 tons of fluorite annually.
ShangraoYinghui Foreign Trade Industrial Co., Ltd.	Production capacity of 60,000 t/y of fluorite (powder, block).	Established in 1997, a comprehensive private company with export & import rights; has its own fluorite mines and concentration plants in Fujian and Shangrao.

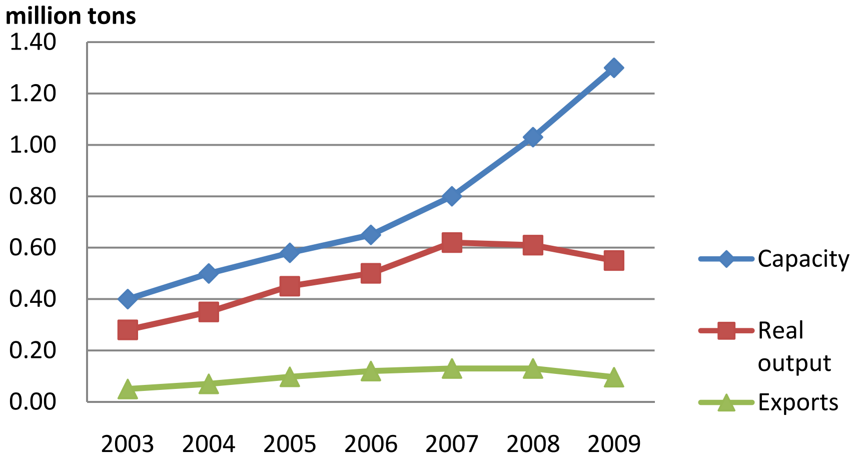
Inner Mongolia Xiangzhen Mining Group Co., Ltd.	Exploitation capacity of 300,000 t/y of ore, beneficiation capacity of 240,000 t/y of ore.	A subsidiary of a US listed company. Owns an especially large high-grade fluorite mine with reserve of 8.14 million tons, ranking first of Asia; the average grade of CaF_2 is 56.98%. Owns an exploitation plant and two concentration plants; the biggest mining-beneficiation integrated enterprise in northern China.
Hunan Wanghua Fluorite Mining Industry Co., Ltd.	Production capacity of 120,000 t/y of fluorite ores, 20,000 t/y of fluorite products and 60,000 t/y of fluorite concentrate.	Producing 1,200 t/y of reagents and tailings baking-free bricks 20 million units per annum.
Guizhou Wuchuan Dongsheng Mining Group	Production capacity of 100,000 t/y of fluorite powder and over 120,000 t/y of fluorite products.	Has four fluorite flotation process lines; the biggest fluorite production and process base in southwestern China.
Hunan Hongan fluorite mine	Has operating mines and a fluorite concentration plant. Production capacity of 60,000 t/y of ores and 60,000 t/y of acidic fluorite concentrate.	
Gansu GaotaiHongyuan Mining Co., Ltd.	Production capacity of 80,000 t/y of fluorite.	
Fujian Jiangyang Kings Fluorite Industry Co, Ltd.	Production capacity of 50,000 t/y of acidic fluorite powder.	A holding company of Sinochem Shanghai, a member of Sinochem Group.
Inner Mongolia Baiyin Mining	Exploitation and beneficiation capacity of 300,000 t/y of fluorite.	Project started in February 2010 with total investment of RMB150 million.
LaifengFurui Mining Co., Ltd.(Hubei province)	Designed capacity of 150,000 t/y of fluorite.	Equipment commissioning in April 2010; major products are fluorites with purity of over 97%; production value can reach RMB 120 million.
Hunan Nonferrous Chenzhou Fluorite Chemistry Co., Ltd.	Designed capacity of 100,000 t/y of fluorite.	Commissioned in early 2010.

Source: Changjing Securities, Chinaqking

3.4. China's Hydrofluoric Acid Production

As illustrated in the figure below, China's production capacity of hydrofluoric acid reached 1.3 million t/y by the end of 2009, which was more than three times the capacity six years ago. The real output though did not grow as rapidly.

Figure II- 4: China's hydrofluoric acid production, 2003 – 2009



Source: Changjiang Securities, Fluorosilicone Association

The table below gives the major hydrofluoric acid producers in China:

Table II- 7: Major hydrofluoric acid producers in China

Name	Production Capacity ('000 tons)
Shandong Dongyue Chemical Co., Ltd.	80
Zhejiang Sanmei Chemical Co., Ltd.	60
Jiangsu Meilan Chemical Group Co., Ltd.	50
Sinochem Environmental Chemical(Ganzhou) Co., Ltd.	45
China Yingpeng Chemical Co., Ltd.	45
Fujian ShaowuHuaxin Chemical Co., Ltd.	45
ChifengDongyueJinfeng Fluorine Chemical Co., Ltd.	40
Guangdong NanhaiShuangfu Chemical Co., Ltd.	40
Jiangxi Yingpeng Chemical Co., Ltd.	40
Fujian ShaowuYongfei Chemical Co., Ltd.	36
Jiangxi China Fluorine Chemical Co.,Ltd.	35
Anhui XuanchengHengyuan Chemical Technology Co., Ltd.	35
Zhejiang Kaisheng Fluorine Chemistry Co., Ltd.	30
Fujian Baotengda Chemical Co., Ltd.	30
Fujian QingliuDongying Chemical Co., Ltd.	30
WuchuanChenheDongsheng Fluorine Co., Ltd.	30
Jiangsu Changshu 3F Zhonghao New Material Co., Ltd.	30
Jiangxi Huaxing Fluorine Chemical Co., Ltd.	30

Source: Changjing Securities, ChemNet

The growth rate of China's hydrofluoric acid production capacity in recent years has enlarged the gap between capacity and real output, which did not grow as quickly. However, given the fact that the hydrofluoric acid is an important raw material for a wide range of further downstream fluorine contained chemical industries, both domestic consumption and demand for China's exports remains strong. Consequently, China's recorded hydrofluoric acid prices showed a stable rising trend in recent years.

Given steady high prices and favorable government support, China is expecting to increase its production capacity for hydrofluoric acid by a further 360,000 tons in the next 3 years or so.

Table II- 8: New hydrofluoric acid production by Chinese companies in the upcoming three years

Name	Production capacity enlargement ('000 tons)
Zhejiang Fuyuan Chemical Co., Ltd.	20
Fujian Yongfu Chemical Co., Ltd.	15
Fujian Gaobao Mining Chemical Co., Ltd. (Qingliu)	30
Fujian Longfu Chemical Co., Ltd.	35
Hangzhou Pigment Chemical Co., Ltd.	15
Changshu 3F Chemical Co., Ltd.	30
Jiangxi Datang Chemical Co., Ltd.	50
Jiangxi Xinkangshun Chemical Co., Ltd.	10
Centralfluor Industries Group JingdexianYangzihenghe Fluorine Chemical Co., Ltd.	30
Jiangxi Yingteng Chemical Co., Ltd.	20
Hebei Paddock	15
Shaanxi Shangzhou Chemical Co., Ltd.	15
WengfuDazhoujian Phosphorus Sulfur Base	10
Inner Mongolia Fengzhen 3F	15
Inner Mongolia Huasheng Hydrofluoric Acid Co., Ltd.	15
Inner Mongolia ChifengAohanYinyi Mining Co., Ltd.	30
FengningAoxiang Group (Inner Mongolia)	15
Tuofu (Inner Mongolia) Chemical Development Co., Ltd.	30
XilinhaoteChifengXingye Group Hydrofluoric Acid Project	30
XiwuqiJintian Anhydrous Hydrofluoric Acid	30
Inner Mongolia Fubang Chemical Co., Ltd.	60
Total	360

Source: Changjing Securities, ChemNet

Taking an industry average of 5 tons of fluorite ore or 2.2–2.3 tons of acid grade concentrate used per ton of hydrofluoric acid, about 1.1 million tons of acid grade concentrate was used in hydrofluoric acid production in 2009. Assuming that the current level of production capacity will be fully utilized within three years, at the end of that period, China's domestic demand for fluorite for use in the chemical industry is expected to exceed 3.5 million tons per year.

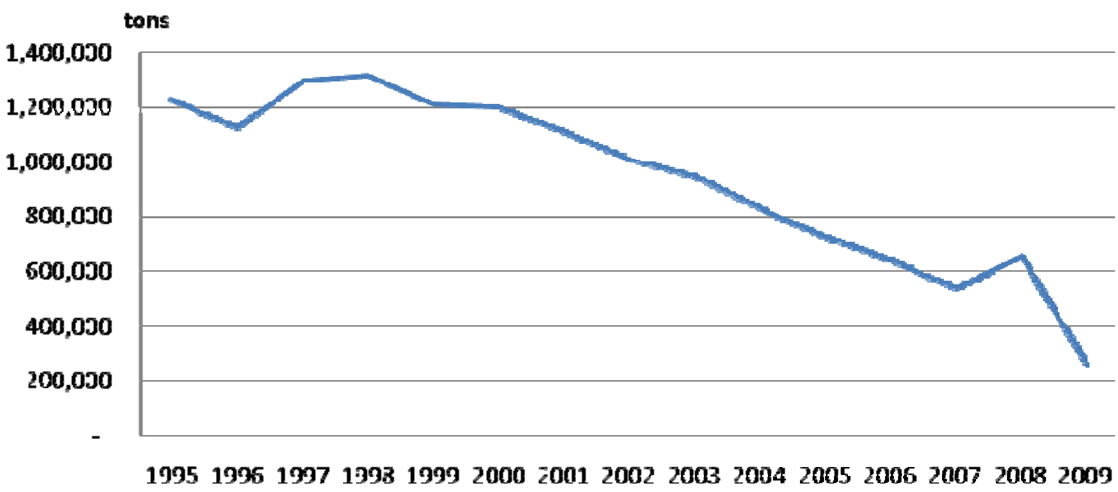
The hydrofluoric acid overcapacity in recent years was also a direct result of tightening policies on the export of China's fluorite resources, which is explained in more detail in Section 3.5 of this report. This was typically the case for those projects located in coastal provinces or close to transportation infrastructure that enables hydrofluoric acid export. Japan, South Korea and Taiwan were the main importers of fluorite resources from China; these countries now increasingly outsource their basic fluorine chemical production through FDI or JV arrangements to counter the impact of the policy changes. It is also highly relevant that a number of speculative private funds have flown into this sector to take an advantage of the relatively stable hydrofluoric acid prices.

At the aggregate level, hydrofluoric acid production capacity is generally planned 2–3 years ahead of the real output level. However, as the growth of global demand for fluorine chemicals decelerated during the Global Financial Crisis, China's hydrofluoric acid production capacity growth did not slow down accordingly. Nevertheless, industry experts and policy makers in China have already started to take cautious views on upcoming new projects in this sector. Many critics are advising the government to raise the bar for entry and to intensify monitoring efforts on suspicious fluorite resource exploitation in disguise.

3.5. China Fluorite Exports

In order to protect and save fluorite resources, China has declared fluorite a strategic resource and implemented an export quota. Since 1999, fluorite export has progressively decreased. In 2009, the total fluorite export volume was only 270,000 tons due to the economic downturn. The fluorite export quota was only 550,000 tons for 2010.

Figure II- 5: China's fluorite exports, 1995 – 2009



Source: Changjiang Securities

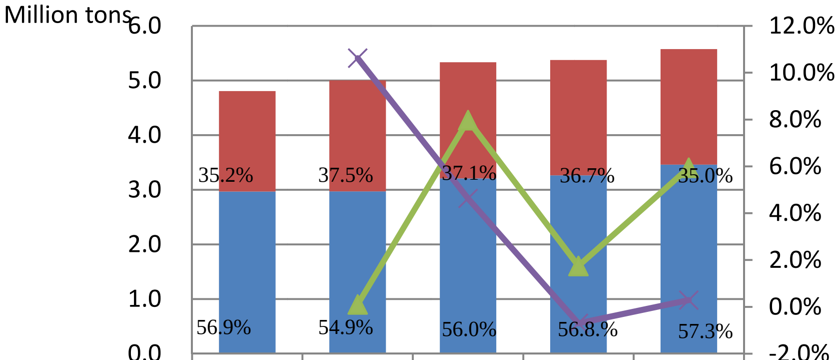
On the other hand, China's hydrofluoric acid exports, which are not restricted by quota, have increased significantly during recent years, from 17,200 tons in 2001 to 133,600 tons in 2008.

4. Global Fluorite Demand Analysis

4.1. Fluorite Demand Structure

The fluorine chemical and metallurgy industries are the main aggregate downstream segment of the world fluorite market. Correspondingly, acid grade and metallurgical grade fluorite are facing high demand, representing 90% of the world total demand. Acid grade itself accounts for over 55% of the total and the figure is still growing.

Figure II- 6: Global acid grade and metallurgical grade fluorite consumption, proportion and growth rates

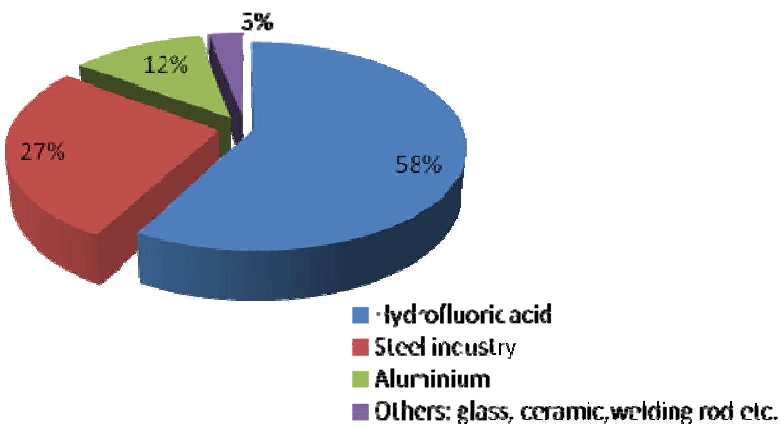


	2004	2005	2006	2007	2008
Metallurgical grade	1.8	2.0	2.1	2.1	2.1
Acid grade	3.0	3.0	3.2	3.3	3.5
Growth Rate (A)		0.1%	8.0%	1.7%	5.9%
Growth Rate (M)		10.6%	4.6%	-0.7%	0.3%

Source: Changjiang Security

The US, Western Europe and Japan represent the largest consumer bases for natural fluorite resources. In 2006, total consumption by these three regions reached nearly half of the world total, at around 2.2 million tons. Over half of the fluorite consumption by the developed world is for hydrofluoric acid production.

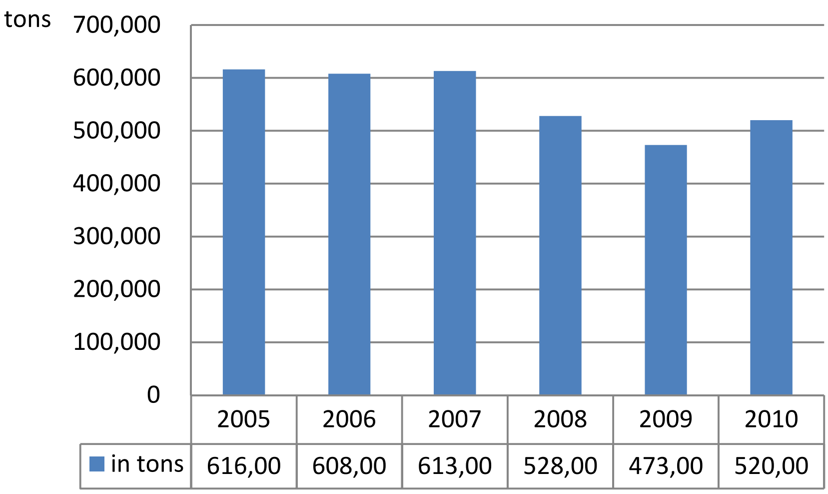
Figure II- 7: Fluorite consumption structure by the developed world



Source: British Columbia Geological Survey

Arkema Group (France), DuPont Group (US), Great Lakes Chemical Corporation (US), Honeywell Group(US), Ineos Group (US), Solvay Group (US) and MDA Manufacturing Inc. (US) are amongst the largest fluorine chemical producers globally. The majority of these companies base their fluorine containing fine chemicals production in the US. In 2008, the apparent fluorite consumption by the US alone reached 528,000 tons, although it dropped significantly from the year before. Of this consumption, 85% was for hydrofluoric acid and aluminum fluoride production in Louisiana and Texas, while steel smelting and other uses made up the other 15%. In 2009, the total reported US fluorite consumption decreased by 10.4% compared to 2008. Acid grade fluorite accounted for 95% of the total US fluorite consumption in that year. The US fluorite demand recovered somewhat in 2010, but was still depressed compared to pre-2008 levels.

Figure II- 8: US fluorite apparent consumption, 2005-2009



Source: USGS

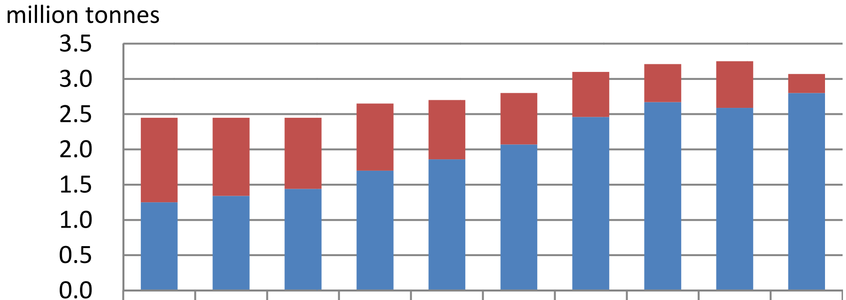
In Western Europe and Japan, the proportions of fluorite used for hydrofluoric acid production are 68% and 44%, respectively.

5. China Dynamics

5.1. China's Demand and Export Balance

In the first half of 2010, the apparent consumption of fluorite in China hit 1.9 million tons. In the full year 2009, that figure was 2.8 million tons, up 8.2% from a year earlier. As can be seen from the figure below, China's fluorite exports have consistently decreased from 2000-2009, at an average annual rate of 14.3% as domestic consumption has increased. However, part of this decline has been offset by the rapidly rising exports of hydrofluoric acid, as described earlier.

Figure II- 9: China's domestic fluorite consumption-export balance

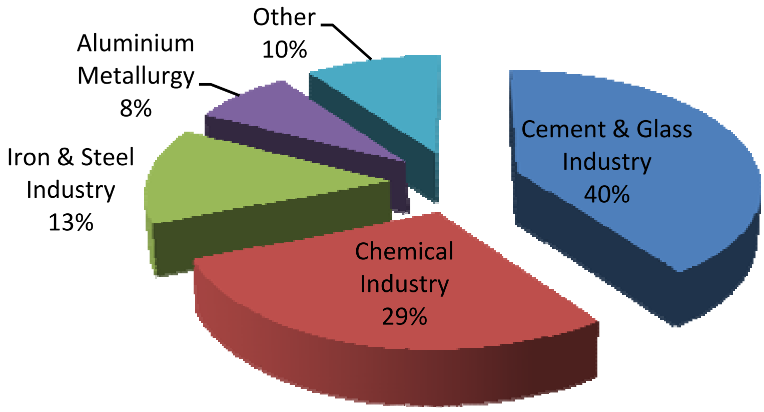


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	1.2	1.1	1.0	1.0	0.8	0.7	0.6	0.5	0.7	0.3
Domestic	1.3	1.3	1.4	1.7	1.9	2.1	2.5	2.7	2.6	2.8

Source: China National Petroleum and Chemical Planning Institute, USGS

China ranks first in the world in terms of fluorite consumption by volume but lags far behind the developed countries in terms of downstream consumption structure. A high proportion of China's fluorite consumption comes from the building material and ceramic industries. This is partially due to the fact that China traditionally had large cement and ceramic/glass industries to support its rapid urban development.

Figure II- 10: China's domestic fluorite consumption structure in 2009



Source: Changjiang Securities

However, as China's industrial structure rapidly evolves alongside its fast-growing economy, the country's fluorite resource use is now shifting towards high value added chemicals.

5.2. China's Policies

Given the limited nature of China's recoverable reserves of fluorite and increased domestic requirements, the Chinese government has implemented a number of policies to restrict fluorite exploitation and encourage in-country production of high value add products.

- **Export quota:**

According to the “Provision on the Export License Administration” released by the Ministry of Foreign Trade and Economic Cooperation, fluorite is included in a set of provisions implemented on January 1, 2000.

On October 29, 2009, the Ministry of Commerce announced the “Agricultural commodities and Industrial Products Export Quota Policy”, which gave an export quota for fluorite of 550,000 tons in 2010. The following table provides the fluorite export quota set for each year from 2003 to 2010.

Table II- 9: China's fluorite export quota, 2003 – 2010

Year	2003	2004	2005	2006	2007	2008	2009	2010
in tons	850,000	750,000	750,000	710,000	685,000	550,000	550,000	550,000

Source: MOFCOM

- **Export tax policies:**

Fluorite: The export VAT rebate rate in 2003 was 13%; in 2004, it was decreased to 5%. In January 2006, China abolished the export VAT rebate for fluorite, and began to impose a tariff of 10% in 2007. In 2008, the export tariff rose to 15%.

Hydrofluoric Acid: China abolished the export VAT rebate of 13% on September 1, 2006, and began to impose an export tax of 10% in January 2007. The export tax rose to 15% in January 2008, and rose again to 25% in January 2009. In order to protect export enterprises, China decreased the export tax to 15% in July 2009 and kept it at that level in 2010.

- **Control over production volume:**

On January 2, 2010, the General Office of the State Council issued the “Implementation of comprehensive measures for controlling of exploitation and production of fireclay fluorite”, which was a request to control fluorite production volume by carrying out measures affecting all aspects of production and sale, including exploitation, taxes, environmental conservation, entering the industry and export management systems

On May 25, 2010, the Ministry of Land and Resources issued the “Notice of Controlling in exploitation volume of high alumina clay and fluorite”. The notice clearly says that fluorite production in 2010 was set at 11 million tons. This was the very first time that China controlled fluorite production. The notice further indicates that China would not permit the opening of new fluorite mines moving forward.

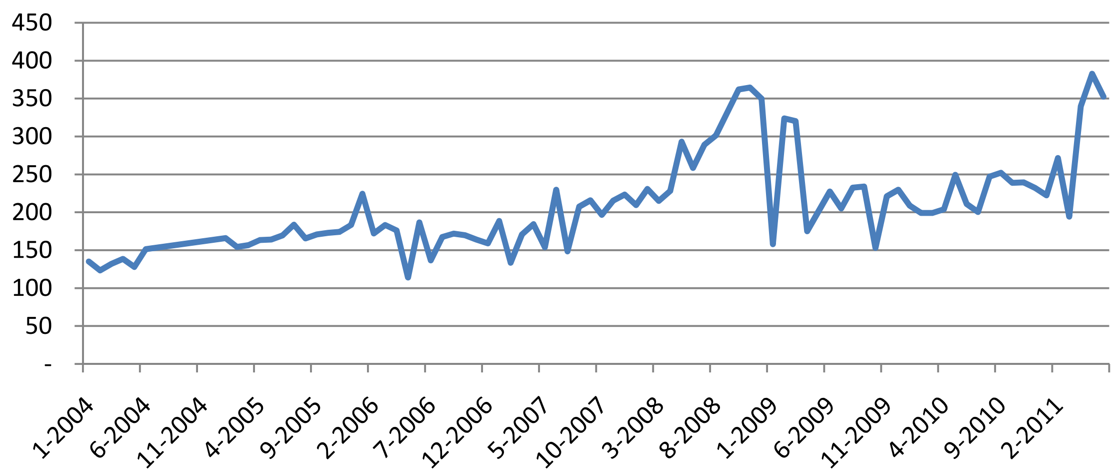
- **Fluorite Resource Tax:**

According to the notice released by both the Ministry of Finance and the State Taxation Administration, the resource tax for fluorite rose from RMB 3 per ton to RMB 20 per ton on June 1, 2006.

6. Pricing

The US started recording fluorite prices some 100 years ago. Before 1970, there were modest variations, but prices generally remained below USD 50 per ton. In the following decade or so, increasing demand quickly pushed the prices up to just below USD 200 per ton. At that time, China was going through its economic reform; when China began allowing the export of raw materials, cheap resources suddenly became available to the rest of the world and fluorite prices in the US rapidly dropped to below USD 100 per ton in the early 1990s. The combination of an unbalanced supply-demand situation and the low prices linked to high volumes of competitively priced Chinese exports resulted in the closure of many fluorite mines, particularly in North America and Europe. Since then, the global market prices for fluorite have been largely in line with China's export prices.

Figure II- 11: China's fluorite export prices (USD/ton)



Source: Bloomberg, China Custom

Antidumping duties against Chinese acid-grade fluorite exports were followed in the late 1990's by the introduction of export quotas and tariffs by the Chinese government. These market events, combined with the existing resources continuously being drawn down, resulted in an increasing trend in the prices for fluorite concentrate. The average price for fluorite exports from China, reached about USD 200 per ton in 2005, nearly doubling since 2000. In the same year, fluorite prices reached USD 235 per ton in US ports. By 2010, China's fluorite export prices stabilized around USD 250 per ton (RMB 1,500 –1,700 per ton). In 2011, however, fluorspar prices have risen rapidly, touching as high as USD 600 per ton for acid-grade fluorspar, driven by recovery in demand and as China focuses on domestic consumption and tightens implementation of environmental regulations, driving up production costs.

In the short term, China will remain a dominant fluorite producer and exporter, and, consequently, will have an ability to influence the global fluorite prices. However, China's dominant position should eventually deteriorate; we have already seen a decreasing trend in both the quantity and proportion of its fluorite exports, despite the fact that the country's overall production have continuously risen.

Part III: Bismuth

1. Introduction to Bismuth and Properties

1.1. Properties of Bismuth

Bismuth is a silver-colored metal with a density of 9.8g/cm^3. It has a low melting point of just above 271°C, and a boiling point of 1560°C. Bismuth has low electrical and thermal conductivity.

Bismuth is the most naturally diamagnetic of all the metals and has the second lowest thermal conductivity after mercury. It has a high electrical resistance, and has the highest Hall Effect of any metal (i.e. the greatest increase in electrical resistance when placed in a magnetic field). When deposited in sufficiently thin layers on a substrate, bismuth is a semiconductor.

Elemental bismuth is one of very few substances for which its liquid phase is denser than its solid phase (water being the best-known example). Because bismuth expands on freezing, it is an important component of low-melting typesetting alloys, which need to expand to fill printing molds. In addition, this property makes bismuth alloys particularly suited to the production of sharp castings of objects subject to damage by high temperatures. Combined with other metals such as tin and cadmium, bismuth forms low-melting alloys which are extensively used for safety devices in fire detection and extinguishing systems. Bismuth is used to produce malleable irons and is also finding use as a catalyst for making acrylic fibers. The metal is also used as a thermo-coupling material, and has found application as a carrier for 235 U or 233 U fuels in nuclear reactors.

1.2. Occurrence and Extraction

Bismuth is rarely found free in nature and is obtained commercially as a by-product of the mining and production of several other metals including lead, tungsten, copper, silver, gold and zinc.

The most common bismuth minerals are bismuthinite and bismite, which are found in minute quantities within the ores of other metals. The Tasna mine in Bolivia is one of the rare mines that have produced bismuth from a bismuth ore, but it has been on standby since the mid-1990s, awaiting a significant rise in the metal price.

According to Umicore, about 90-95% of bismuth production is obtained as a by-product of lead refining. When lead is refined by electrolysis, impure bismuth metal is recovered from the anode slimes. The impure metal is refined using either a thermal or a conventional route consisting of a series of operations similar to those used in lead refining. The final product can be almost 100% pure. The metal is converted into ingots, powder, pieces, shot, and pellets.

Another important source of bismuth is the recycling of lead-acid batteries, where the metallic stream mixture yields metallic bismuth via a pyrometallurgical process (also known as fusion-reduction methods), a hydrometallurgical (electrolytic) process, or a combination of both.

1.3. Specifications of Bismuth

Bismuth metal may be supplied in the form of ingots, needles, pellets or powder, with variations such as discs, granules, pieces, rods, sputtering targets, wires, and various custom shapes. Bismuth ingots are used mainly as metallurgical additives and in making fusible alloys. Bismuth needle is used mainly in the manufacture of bismuth compounds for pharmaceutical and catalyst applications. Bismuth powder is produced in varying mesh sizes for electronic applications. Bismuth pellets are used as metallurgical additives.

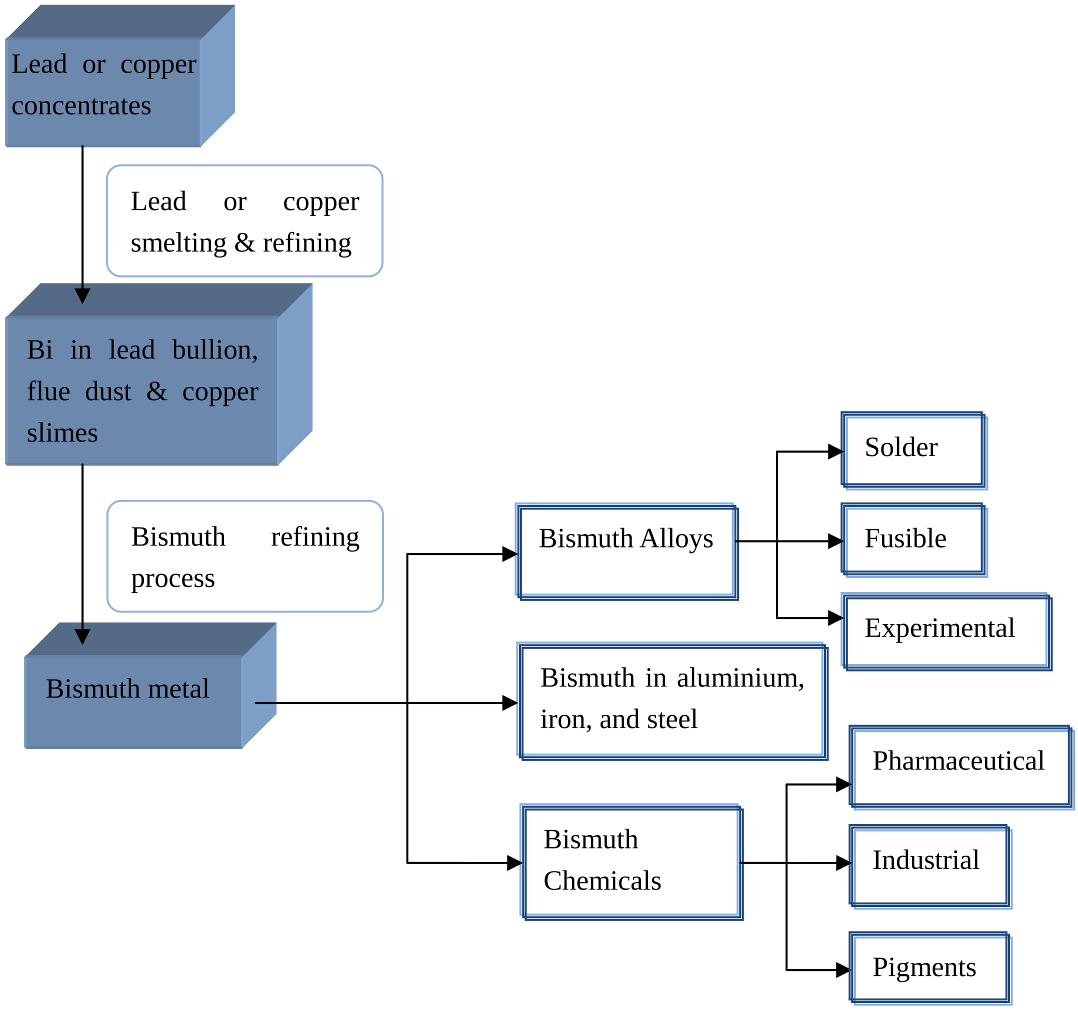
Bismuth metal and compounds are available with purities from 99% to 99.9999% (ACS grade to ultra-high purity). The ultra-high purity and high purity forms include metal powder, submicron powder and nano-scale, quantum dots, targets for thin film deposition, pellets for evaporation and single crystal or polycrystalline forms.

Other common forms include fluorides, oxides, chlorides and solutions.

2. Value Chain of the Bismuth Industry

Though bismuth metal is not used commercially as is, it finds application in a variety of uses as alloys with other metals, additives and in the pharmaceutical and chemical industry.

Figure III- 1: Value chain of the bismuth industry



Source: Market Study on Bismuth, Peter Harben, Peter W. Harben, Inc., Las Cruces, New Mexico & Edward Dickson, TAK Consulting, London, UK

2.1. Bismuth Uses

Bismuth has a wide range of applications, including uses in metallurgy, low-melting alloys, chemistry, electronics and others. Within each of these applications, bismuth is used in small quantities.

2.1.1. Metallurgy

Metallurgical Additives: Bismuth is used as an additive in the manufacture of free-machining steel and free-machining aluminum. The bismuth enhances the action of lead in the steel by lowering the frictional resistance at the cutting edge of the tool, resulting in thinner and smaller chips, higher productivity, and improved surface finish. Bismuth is also used as a hardening agent in lead-acid automotive and standby batteries and amalgams.

Molds and Molded Products: Most molten metals shrink and pull away from molds when they solidify, failing to reproduce fine detail. Fusible alloys, conversely, expand and push into mold detail when they solidify, a quality that, along with low melting temperature and ease of handling, explains their extensive use in duplication and reproduction processes. This is also a valued property when used in soldering or joining of pipes in plumbing.

Malleable irons: Many bismuth alloys are relatively malleable and can be hammered into thin sheets. Bismuth is alloyed with iron to create "malleable irons," which provide a combination of strength, wear and fatigue resistance, toughness, and ductility characteristics.

2.1.2. Low-melting Alloys

When combined with other metals such as tin and cadmium, bismuth metal forms low-melting alloys (sometimes called fusible alloys).

These low-melting alloys are suitable for the wide variety of applications, including tube bending; anchoring for aligning and setting punches in a die plate; supporting delicate materials without distorting; shielding against radiation during radiation therapy; and eliminating interference through electromagnetic and radiofrequency shielding. They can reproduce extremely fine detail and are used in modeling and molding. They are also used in fusible safety devices such as fire alarm plugs that melt to turn on the system.

Bismuth acts very much like lead in many respects. However, unlike lead, bismuth is not known to be toxic to humans except in the consumption of immense doses. In the early 1990s, bismuth was evaluated as a nontoxic replacement for lead in products ranging from free-machining brasses for plumbing applications to shot for waterfowl hunting and fishing sinkers.

2.1.3. Bismuth Compounds

Various bismuth compounds are used in the manufacture of drugs, pharmaceuticals, and other bismuth-based chemicals. Bismuth oxide is the most important industrial compound of bismuth and, along with bismuth nitrate, a starting point for bismuth chemistry.

Bismuth Oxide: This is highly insoluble, thermally stable bismuth source is suitable for glass, optic and ceramic applications. They are typically insoluble in water and extremely stable, making them useful in ceramic structures as simple as clay bowls, and as advanced as electronics, aerospace and electrochemical applications. Metal oxide compounds react with acids and with strong reducing agents in redox reactions. They are available in powders and dense pellets for optical coating and thin film applications.

Bismuth Nitrate: In contrast to the oxide, this is a highly water-soluble crystalline bismuth source. Nitrate compounds are also oxidizing agents. When mixed with hydrocarbons, they can form a flammable mixture. Nitrates are excellent precursors for the production of ultra-high purity compounds and certain catalyst and nano-scale materials. Bismuth subnitrate is more astringent than other bismuth salts and is used a wound dressing and in cosmetic creams. Bismuth subnitrate also produces an iridescent luster finish as a component of glazes.

Other Bismuth Chemicals: Fluoride compounds are another insoluble form that can be used in situations where oxygen is undesirable, such as metallurgy, chemical and physical vapor deposition, and in some optical coatings. In extremely low concentrations (ppm), fluoride compounds are also used in health applications.

Bismuth acetate is a moderately water-soluble crystalline bismuth source that decomposes to bismuth oxide on heating and is an excellent precursor for production of ultra-high purity compounds and certain catalyst and nano-scale materials.

Various other bismuth compounds have applications in medicine, electronics, cosmetics, coatings, glass and ceramics, pyrotechnics, catalysts, EP-greases, lubricants, and other industries.

3. Global Bismuth Supply Analysis

3.1. Global Bismuth Reserves

World reserves of bismuth are usually based on the bismuth content of lead resources because bismuth production is most often a byproduct of lead ore processing. However, in China, bismuth production is also a byproduct of tungsten and other metal ore processing. World bismuth reserves are estimated to be about 320,000 tons of metal contained. The major deposits lie in China, Australia, Peru, Mexico, Bolivia, United States, Canada and Japan. China has the largest reserves of bismuth in the world – about 240,000 tons of metal contained, or 75% of global reserves.

Table III- 1: World mine production and reserves (tons of metal contained)

Country	Mine production		Reserves
	2009	2010^{e}	
China	6,000	5,100	240,000
Peru	1,000	1,100	11,000
Mexico	900	1,000	10,000
Kazakhstan	150	140	5,000
Canada	90	100	5,000
Bolivia	50	150	10,000
Other	10	10	39,000
Total	**8,200**	**7,600**	**320,000**

Source: USGS ^{e}: estimated

3.2. China's Bismuth Reserve

China has 70 locations with bismuth reserves, of which six mines have reserves of over 10,000 tons of metal contained, representing 78% of China's total. Two other mines have reserves of over 50,000 tons of metal contained. Hunan, Guangdong and Jiangxi lead the supply of bismuth with about 85% of the total reserves in China, with the remaining reserves mostly in Yunnan, Inner Mongolia, Fujian, Guangxi and Gansu.

3.3. Global Bismuth Production

The major suppliers of bismuth are China, Peru and Mexico.

3.3.1. China

According to estimates, there are about 50 producers of bismuth in China, mostly located in Hunan and Jiangxi provinces. Hunan Bismuth Co., Ltd. is the largest producer of bismuth metal ingot, with about 50% of total production in China in 2010.

Table III- 2: The major players at each step of the value chain

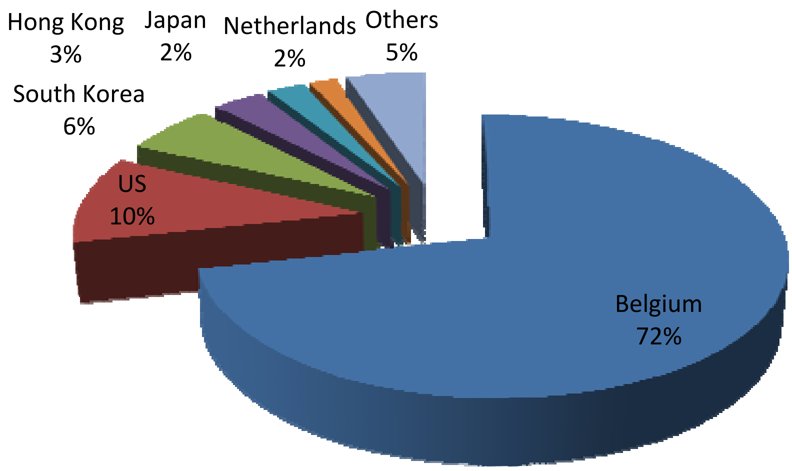
Bismuth concentrate	Bismuth metal	Bismuth oxide
Hunan Shizhuyuan (Capacity: 600 metal t/y) SOE	Hunan Bismuth Co., Ltd. (Capacity: 3,000 t/y) SOE	Xianyang Yuehua (Capacity: 1000 t/y) Private
Jiangxi Tungsten Industry Group SOE	Hunan Jinwang (capacity: 800 t/y) Private	MCP (Capacity: 1000 t/y) Belgium
Inner Mongolia Xingye Group	Jiangxi Copper Co. (Production in 2010: 628 t) SOE	Hunan Jinwang (Capacity: 600 t/y) Private
	Hunan Shizhuyuan (Capacity: 1200 t/y)	Beijing Dangsheng (Capacity: 300 t/y) SOE & A share listed Company

Source: Somerley

The output of bismuth as a byproduct is increasing, benefiting from the output increases of lead, copper and iron. Bismuth raw materials mainly come from lead slimes, copper smelting flue dust, tin slimes, blast furnace flue dust from smelting pig iron, and bottom Pb-Bi alloy.

China's total export volume is increasing, but the export percentage in the total production is decreasing because domestic consumption is growing faster.

Figure III- 2: China bismuth export distribution in 2010



Source: 2010 Bismuth Market Annual Report, Asian Metal Limited

Table III- 3: China bismuth export in 2010

	Unwrought	Wrought	Total
	ton	ton	ton
Belgium	2,933	1,713	4,646
United States	149	523	672
South Korea	165	214	379
Hong Kong	5	203	208
Japan	13	141	154
Netherlands	95	13	108
Others	48	277	325
Total	**3,408**	**3,084**	**6,492**

Source: 2010 Bismuth Market Annual Report, Asian Metal Limited

Belgium remained the largest buyer of bismuth in 2010 with 72% of the total export. The export to the United States, South Korea, Japan and Netherlands were also over 100 tons.

3.3.2. Peru

Doe Run Peru SRL: Doe Run Peru operates the La Oroya metallurgical complex in Huancavelica Province in Peru's central Andes. The complex, in operation since 1922, produces copper, lead, zinc, bismuth, silver, and indium.

Antamina Copper and Zinc Mine: Owned by Teck Cominco Limited (22.5%), BHP Billiton (33.75%), Xstrata plc (33.75%), and Mitsubishi Corporation (10%) via the Peruvian company Compañía Minera Antamina S.A. (CMA), Antamina is a source of copper and zinc concentrate containing bismuth. The complex ores are processed at the concentrator plant in Yanacancha with a design capacity of 70,000 tons/day but is capable of processing 80,000 tons/day of up to six different types of minerals. The concentrate is shipped to refineries and smelters worldwide.

3.3.3. Mexico

Met-Mex Peñoles, S.A. DE C.V., part of the Industrias Peñoles Group, produces about 1,200 t/y of bismuth. The company's non-ferrous metallurgical complex in Torreón, Coahuila is the world's largest producer of refined silver and metallic bismuth (99.9970% Bi) with a capacity of 2,000 tons of bismuth.

Bismuth is also produced at an electrolytic zinc refinery at San Luis Potosí operated by Industrial Minera Mexico S.A. (Grupo Mexico).

3.3.4. Belgium / the UK

Société Industrielle d'Etudes et d'Exploitations Chimique S.A., or Sidech S.A., claims to be the world's only specialist and leading producer of bismuth, with a capacity of 2,000 t/y. The Belgian company's integrated process treats various kinds of bismuth-containing materials, in particular lead-bismuth by-products from lead refineries, to yield bismuth ingots, shots, needles, pellets, powder, alloys, and compounds.

In September 2007, the MCP Aramayo Group from the UK and Sidech announced that the two company's operations would be merged to form MCP Group S.A.. In April 2011, 5N Plus Inc. acquired MCP Group S.A.. Reportedly, the MCP Group S.A. has secured much of the mined output of bismuth from China. In addition, it has signed offtake agreements with Nui Phao Mining in Vietnam (2,000+ t/y by 2013) and Fortune Minerals in Canada (650 t/y by 2011).

3.4. Expected Changes in Supply

There are several bismuth-containing deposits in varying stages of mining feasibility review. These polymetallic deposits include NICO in Canada and Nui Phao in Vietnam.

<u>Fortune Minerals</u>: Canada's Fortune Minerals is conducting a feasibility study of the NICO gold-cobalt-bismuth asset, northwest of Yellowknife. If it proves to be feasible, the site will undergo both underground and open pit mining, and will produce bismuth concentrate, cobalt and gold.

<u>Nui Phao Mining</u>: Vietnam's Nui Phao Mining, owned by Masan Group, controls one of the largest single point producers of bismuth, tungsten, and acid-grade fluorspar in the world. Nui Phao Mining has a reserve of around 50,000 tons of bismuth, which could support production for 16 years.

4. Global Bismuth Demand Analysis

Since the early 1990s, worldwide demand for bismuth has doubled to almost 6,000 tons, driven by increased use in applications such as paint, pigment, and metallurgy. According to Lei Xiaohua, Deputy Sales Director of Hunan Shizhuyuan in China, the annual consumption of bismuth ingot has been growing by about 10–15% in recent years. The major consuming countries are the US, Japan, China, the EU, Korea, and India. Among them, China, Japan and Korea showed higher growth rates than the others. In 2008, the reported consumption in the US was 1,090 tons with a value of approximately of $19 million, of which about 60% was in pharmaceuticals and chemicals, 36% in metallurgical additives, and 4% in fusible alloys, solders and ammunition cartridges. In 2008, the consumption in China was 2,965 tons, including 800 tons in medicine (27%), 1,965 tons in bismuth oxide (66%), and 200 tons in alloy (7%).

Meanwhile, bismuth requirements in many other fields have been increasing. Demand from the production of Cu-Bi alloy and Sn-Bi alloy has been escalating, and more bismuth is being used as a metallurgical additive for forging iron and special steel. Bismuth replaces lead in solder production in Europe, Japan, and North America, also boosting bismuth consumption.

Bismuth acts very much like lead in many respects. Its consumption as an environmentally friendly substitute for lead has been substantial as lead has been phased out of many applications such as plumbing fixtures, fishing weights, hunting ammunition, lubricating greases, and soldering alloys. In the early 1990s, driven by occupational safety and health concerns about lead and tightening regulations, bismuth was evaluated as a nontoxic replacement for lead in products ranging from free-machining brasses for plumbing applications to shot for waterfowl hunting and fishing sinkers. With the move to lead-free solders, world bismuth consumption is expected to increase by some 25% while lead consumption is reduced by only 0.8%.

Nevertheless, bismuth faces competition as a lead substitute from tin, tungsten, and certain soft steels. For example, various formulas have been developed for non-lead gunshot formulation, and bismuth can be replaced in pharmaceutical applications by alumina, antibiotics, and magnesia. Titanium dioxide-coated mica flakes and fish scale extracts are substitutes in pigment uses. Indium can replace bismuth in low-temperature solders. Resins can replace bismuth alloys for holding metal shapes during machining, and glycerin-filled glass bulbs can replace bismuth alloys in triggering devices for fire sprinklers. Free-machining alloys can contain lead, selenium, or tellurium as a replacement for bismuth.

5. China Dynamics

In line with China's policies to protect other natural resources, China has been consolidating the bismuth industry and implementing stricter environmental norms, in addition to licenses for exporting bismuth and its products.

- **Export license:**

  According to regulation by the Ministry of Commerce of the People's Republic of China ("MOFCOM"), from 2007, China started imposing an export license policy on minor metals including bismuth, which includes unwrought waste bismuth, powder, other bismuth and its articles. Further changes to China's bismuth export strategy look unlikely in the short term, according to industry insiders. It is expected that an export quota may be imposed on bismuth in the future.

- **Key nonferrous metal:**

  Bismuth is defined as a key nonferrous metal, and local governments such as the Hunan government have plans to purchase bismuth to store. If these plans are implemented, it will affect the supply and therefore the price of bismuth.

- **Industry consolidation:**

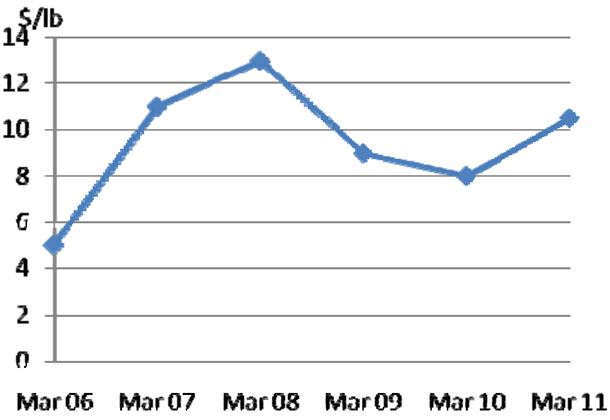
  China's government is putting pressure on bismuth producers to protect the environment, resulting in small-sized producers being forced out of the industry. In 2008, the Hunan Bismuth Co., Ltd. was established by six major bismuth companies in Hunan Chenzhou city. The Company has plans to control upstream bismuth resources through the acquisition of a smelting company, and they are targeting a Hunan local company for a bismuth recycling project. Hunan Bismuth will also focus on the deep processing of bismuth to produce high-end bismuth products. Hunan Chenzhou city is set to become China's "City of Bismuth", and insiders expect that industry concentration would be further enhanced.

6. Pricing

6.1. Historical Price

Bismuth prices rose in 2007 on the back of industry consolidation and China's policies on exports. In 2008-09, prices fell as the global financial crisis depressed prices of all commodities. However, prices have risen sharply since as demand has rebounded and China imposes stricter environmental laws on the mining industry.

Figure III- 3: Bismuth ingot 99.99% FOB warehouse US (USD/lb)



Source: www.metalprices.com

6.2. Demand-Supply Analysis

Demand will continue to increase in 2011, especially as economies in overseas markets start to improve. In 2010, the export of bismuth showed an extraordinary increase. China will remain the leading producer and supplier of bismuth in the global market.

In the long term, as a nontoxic metal, bismuth usage is expected to expand. In the electronics industry, bismuth is set to take the place of lead in many applications. In 2006, the EU launched a regulation prohibiting the usage of toxic material in electronics and electric equipment. In 2007, Samsung Electronics, LG Electronics and Daewoo Electronics in South Korea started plans to produce lead-free plasma display panels, and Samsung Electronics started using bismuth metal in its production of plasma display panels in 2008. In the chemical industry, REACH has launched relevant assessment and permission regulations on chemicals. In 2005, Japan used bismuth instead of lead to manufacture car glass. In the alloy industry, the demand for bismuth as additive in special steel is on the rise. In the welding flux field, Japan, North America and Europe have come to an agreement to try to stop using lead.

Moreover, demand for bismuth is expected to increase continuously based on new uses in superconductive material, new materials, catalysts, nucleus fuel, and others. The expansion of bismuth usage should be a strong support for price increases in the future.

Part IV: Copper

1. Introduction to Copper and Properties

1.1. Properties of Copper

Copper is considered the first metal that human used in production, having been used for thousands of years. However, more than 95% of all copper ever mined and smelted was extracted after 1900.

Pure copper is malleable, softer than iron but harder than zinc, and corrodes only slowly in moist air. It can be polished to a bright finish, and can be readily worked, brazed and welded. As a major commercialized metal, copper offers a wide range of properties, including high thermal and electrical conductivity, outstanding corrosion resistance, good strength and fatigue resistance. It is widely used as a conductor of heat and electricity and a building material. Copper is also a constituent of various metal alloys. Brass, one of the most useful alloys for its ability to be cast or machined, is an alloy of copper and zinc. Bronze, the first alloy ever to be made by humans, usually refers to copper-tin alloys, but can be any alloy of copper, such as aluminum bronze. Copper is also a key constituent of the carat silver and gold alloys used in the jewelry industry, modifying the color, hardness and melting point. The alloy of copper and nickel, called cupronickel, is often used for the outer cladding in low-denomination statuary coins.

Table IV- 1: Summary of copper's properties and related applications

Property	Industrial applications
Aesthetics	Architecture, sculpture, jewelry, clocks and cutlery
Bactericide	Hardware, marine combustion engines, preservation of food and wood
Biofouling resistance	Hydraulic and marine engineering, metalworking, aerospace, power generation, shipbuilding, offshore oil and gas platforms
Corrosion resistance	Plumbing tubes and fittings, general and marine engineering, chemical engineering, industrial processes, desalination, textiles, papermaking
Ease of fabrication	All of the above, plus printing
Electrical conductivity	Electrical power generation, transmission and distribution, communications, resistance welding, electronics
Environmental friendliness	Essential for the health of humans, animals and crops
Low temperature properties	Cryogenics, liquid gas handling, superconductors
Mechanical strength/ductility	General engineering, marine engineering, defense, aerospace
Non-magnetic	Instrumentation, geological survey equipment, offshore drilling
Elasticity	Electrical springs and contacts, instrument bellows, electronic packaging
Thermal conductivity	Heat exchangers and air-conditioning/refrigeration equipment, automotive radiators, internal combustion engines, mining

Source: Copper Development Association

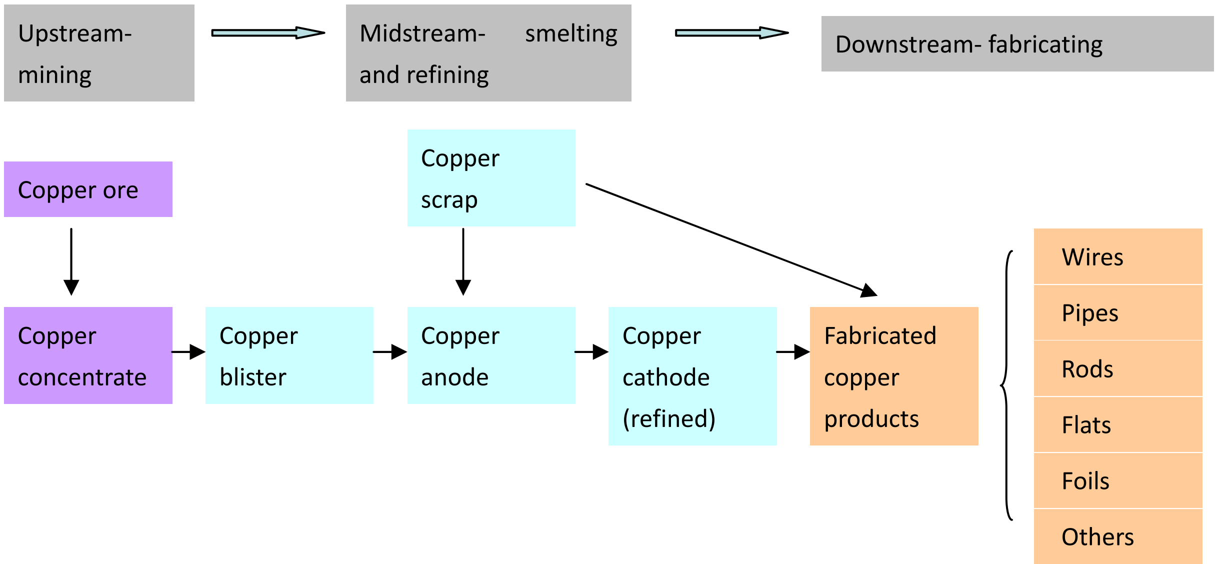
1.2. Occurrence

Copper can be found either as native copper or as part of minerals. Native copper contains more than 99% copper, but there is very little native copper reserve on earth. Copper minerals are much more common, mainly in the form of copper sulfides such as chalcopyrite and chalcocite, copper carbonates such as azurite and malachite, and copper oxides such as cuprite. Copper sulfides contain only 2-3% copper, but are found in huge quantities; more than 80% of the copper ever extracted came from copper sulfides. Chalcopyrite, in the copper sulfides category, is the most abundant and economically significant copper mineral.

2. Value Chain of the Copper Industry

Copper, in its natural mineral form, goes through a series of concentrating, smelting, refining and fabricating steps before it is suitable for end users.

Figure IV- 1: Value chain of the copper industry.



Source: National Trust

<u>Copper ore mining and quarrying</u>: The first step for all copper production is to mine sulfide and oxide ores through digging or blasting, then crushing into walnut-sized pieces. Sulfide ores move on to the concentrating stage, while oxide ores are routed directly to leaching tanks.

According to a research report by National Trust, the scarcity of resources means that copper ore mining furnishes the vast majority – more than 90% – of the profit of the whole value chain.

<u>Copper concentrating</u>: Copper concentrate is the first commercial product line and is composed of approximately equal part of copper, iron and sulfide. The concentrate from different regions can contain approximately 24% to 36% copper. Once copper has been concentrated, it can be turned into pure copper cathode. Copper concentrate can also be sold directly to users.

<u>Smelting and refining</u>: The two most common methods for refining copper are called pyrometallurgy process and hydrometallurgical process, which are used on sulfide copper ores and oxide copper ores, respectively. Smelting and refining copper produces copper cathode.

Treatment and refining charges usually account for approximately 20% of the price of refined copper. The profit at this stage is much smaller than at the mining stage. Table 2 below shows the treatment charges/refining charges (TC/RC) data for the most recent five years.

Table IV- 2: TC/RC from 2006-2010

Cost/Year	2006	2007	2008	2009	2010
TC(USD/DMT)	95	60	45	75	46.5
RC(USc/lb)	9.5	6	4.5	7.5	4.7

Source: Jiangxi Copper Industry presentation

Fabricating: Copper cathode is then fabricated into products that can be used directly, such as cables and tubes, or into semi-finished products which need to be further processed by the downstream value chain, such as copper sheets and strips. Copper can be produced as either a primary product or a co-product of gold, lead, zinc or silver.

Recycling: Unlike most other materials, copper can be 100% recycled repeatedly without losing its chemical or physical qualities.

3. Global Copper Supply Analysis

3.1 Global Copper Reserves

Copper is a fairly common element, existing in both land and deep-sea nodules, and with an estimated concentration of 50-70 ppm in the Earth's crust. If all this copper were extractable, humans would have a nearly inexhaustible supply of the element. Unfortunately, most of it can't be extracted profitably at the current level of technology. At present, copper deposits are considered potentially profitable if they are located sufficiently close to the surface and contain at least 0.3-0.5% copper.

According to USGS, global copper reserves were 635 million tons in 2010. In addition, about 700 million tons of copper is estimated to exist in undiscovered porphyry copper deposits.

Table IV- 3: World major copper resources countries in 2010

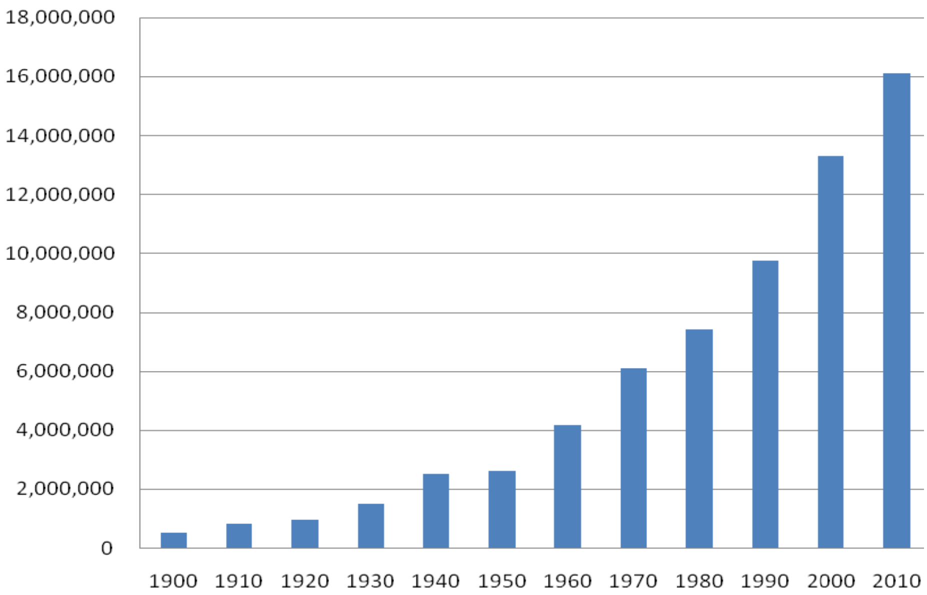
Country	Recoverable Reserves (million tons)	Proportion
Chile	150	23.6%
Peru	90	14.2%
Australia	80	12.6%
Mexico	38	6.0%
United States	35	5.5%
China	30	4.7%
Indonesia	30	4.7%
Russia	30	4.7%
Poland	26	4.1%
Zambia	20	3.1%
Kazakhstan	18	2.8%
Canada	8	1.3%
Other countries	80	12.7%
World Total	**635**	**100%**

Source: USGS

3.2 Global Copper Production

The world's copper production has increased for over a century, and increased dramatically in the past 25 years. The figure below summarizes the copper mine production over the past century.

Figure IV- 2: Copper mine production in the last century



Source: USA Department of the Interior, USGS; Multi Commodity Exchange of India Ltd

The risk of disruption to the global copper supply is considered to be low because copper production is globally dispersed and is not limited to a single country or region. In the past 20 years, the Andean region of South America has emerged as the world's most productive copper region. In 2007, about 45% of the world's copper was from the Andes Mountains. The United States produced 7% of global copper in 2010; all copper produced in the United States comes from, in decreasing order of production, Arizona, Utah, New Mexico, Nevada and Montana.

The table below shows world mine production from 2006 to 2010.

Table IV- 4: World copper mine production ('000 tons)

Country	2006	2007	2008	2009	2010[e]
Australia	859	870	886	854	900
Canada	607	589	607	491	480
Chile	5,360	5,560	5,330	5,390	5,520
China	890	946	950	995	1,150
Indonesia	816	797	651	996	840
Kazakhstan	457	407	420	390	400
Mexico	338	347	247	238	230
Peru	1,049	1,190	1,270	1,275	1,285
Poland	512	452	430	439	430
Russia	725	740	750	725	750
United States	1,200	1,170	1,310	1,180	1,120
Zambia	476	520	546	697	770
Other Countries	1,835	1,840	2,030	2,190	2,300
Total	**15,100**	**15,400**	**15,400**	**15,900**	**16,200**

Source: USGS; [e]: estimated

Chile is the number one producer in mine production with no peers, but in smelter and refinery production, China exceeds Chile as the biggest. Japan, even though not a major mine producer, is one of the biggest copper smelters and refiners. Conversely, Australia, a major mine producer, is not as active in smelter or refinery production. Canada, Russia, Poland, the US, Peru and Indonesia are also major copper producers.

3.3 Major Copper Producers

In 2010, Chile was the largest copper producer in the world, with an output of 5,520,000 tons. The largest copper mine in Chile is the Minera Escondida, which represents approximately 23.5% of Chilean production.

Peru took the second spot in copper production, producing 1,285,000 tons. Peru's largest copper producer is Southern Peru Copper Corporation.

The third largest producer was China at 1,150,000 tons. The US took the fourth spot in copper production, with an output of 1,120,000 tons in 2010. There are two major copper mines in the US:

the Bingham Canyon Mine owned by Rio Tinto Group and the Morenci mine.

The table below summarizes the largest copper companies in the world.

Table IV- 5: Major copper company producers in the world

	Name	Description	2010 Production (tons)
1	Codelco	Chilean state-owned copper mining company formed in 1976; the largest copper producing company in the world; owns the world's largest known copper reserves and resources which, in total, were 118 million tons at the end of 2007.	1,757,000
2	Freeport-McMoRan	The world's lowest-cost copper producer and largest publicly traded copper and molybdenum producer; acquired Phelps Dodge in 2007.	1,441,000
3	BHP Billiton	A global mining, oil and gas company, operating the Escondida mine in Chile, which is the world's largest single mine producer of copper; primary products include copper concentrate and copper cathodes.	1,235,000
4	Xstrata Plc	A global mining company headquartered in Switzerland and listed in London and Switzerland; founded in 1926.	907,000
5	Rio Tinto Group	A global mining group founded in 1873, operating copper projects in America, Africa, Australia and Asia.	701,000
6	Anglo American Plc	A global mining company headquartered in London, with interests in six operations in Chile.	645,000
7	Grupo Mexico SA	Founded in 1988, the largest mining corporation in Mexico; responsible for 87.5% of Mexico's copper production.	598,000
8	Glencore	A multinational mining and commodities trading company headquartered in Switzerland.	542,000
9	Southern Copper Corporation	Founded in 1952, the world’s largest publicly traded and the seventh largest copper mining company; the eighth largest copper smelting company; mainly operating in Mexico and Peru.	487,000
10	KGHM PolskaMiedz SA	One of the largest copper producers in the world; based in Poland and is one of the largest Polish exporters.	426,000

Source: National Mining Association

3.4 Trends in Production

Global production of copper has always steadily increased. Total world production of refined copper increased from less than 8.8 million tons in 1976 to more than 19.2 million tons in 2010.

Recycling of copper, including production of secondary refined copper and direct scrap used by manufacturers, has also been increasing. An increase in the proportion of new scrap relative to post-consumer recycling is partially explained by the expansion of copper manufacturing activities that generate new scrap.

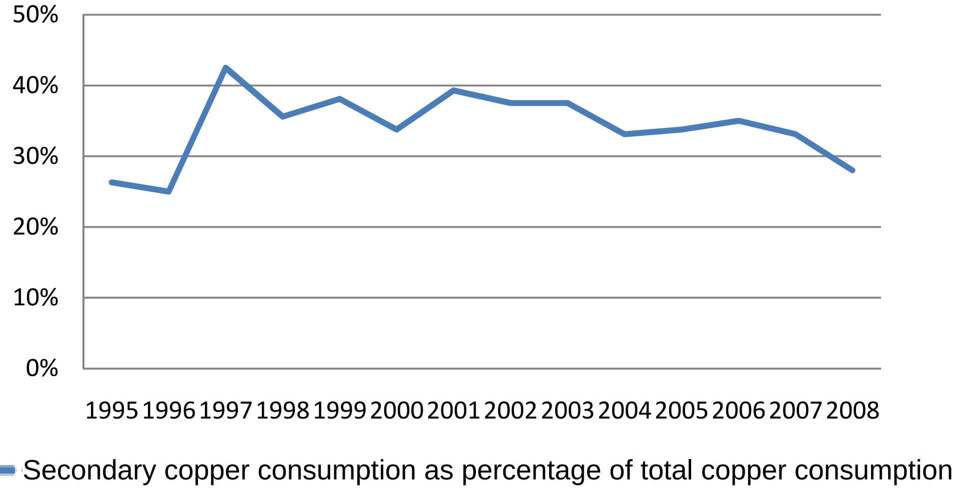
Despite depletion of the richest ores and a shift to less concentrated ores, advances in mining technologies have helped to increase copper production. The supply of this metal is sustainable for the foreseeable future.

3.5 Secondary Consumption

Unlike fossil fuels, copper is usually scrapped and reused because recycled copper and its alloys can be re-melted and used directly or further reprocessed to refined copper without losing any of the metal's chemical or physical properties. Moreover, scrapped copper has several advantages over primary copper. Firstly, according to the Copper Development Association, the cost of recycled copper is roughly 10% less than newly refined copper. Secondly, energy consumption and pollutants emissions in the processing of secondary copper are both much lower than for primary copper.

Developed countries place a lot of emphasis on the reuse of copper. During the past ten years, secondary copper production has accounted for about 40-55% of primary copper. The secondary/primary ratios in the US, Japan and Germany are 60%, 45% and 80% respectively. China is one of the largest scrap copper importing countries, with import from the US and Japan accounting for 38% and 25% respectively.

Figure IV- 3: World secondary copper usage



Source: National Trust

3.6 Expected Changes in Supply

The table below lists the potential new copper mines in the world planned to commission from 2009 to 2013; they, in total, will increase world production capacity by about 3,096,000 t/y.

Table IV- 6：Expected world copper mine production capacity increase

Program	Country	Status	Reserve ('000 tons)	Production('000 tons)	Commissioning time	Mining cost($/lb)
TenkeFungurume	D.R.Congo	Preproduction	5,829	115	2009	< 0.19
Boleo	Mexico	Preproduction	2,929	56	2010	<0.07
Muliashi North	Zambia	Preproduction	695	60	2009	0.24
Rosemont	USA	Feasibility study	2,874	106	2010	0.38
Miheevskoye	Russia	Feasibility study	1,584	81	2009	0.39
Rio Blanco	Peru	Feasibility study	7,107	191	2011	0.41
Galeno	Peru	Feasibility study	4,301	144	-	0.49
Toromocho	Peru	Feasibility study	10,026	250	2012	0.51
Quellaveco	Peru	Feasibility study	7,047	200	2012	0.55
OyuTolgoi	Mongolia	Feasibility study	31,337	440	2011	0.64
El Arco	Mexico	Feasibility study	5,267	188	2011	0.65
Tia Maria	Peru	Feasibility study	2,257	120	2010	0.65
Los Chancas	Peru	Feasibility study	1,997	80	2013	0.65
Marcona copper	Peru	Feasibility study	3,063	60	2009	0.69
Tanpakan	Philippines	Feasibility study	12,890	300	2013	0.70
MinereMusoshi	D.R.Congo	Preproduction	2,471	58	2009	0.71
Costancia	Peru	Feasibility study	1,798	90	2012	0.74
Yandera	Papua New Guinea	Feasibility study	2,253	100	2011	0.75
El Morro	Chile	Feasibility study	7,046	172	2011	0.76
Mirador	Ecuador	Preproduction	4,978	62	2009	0.84
Petaquilla	Panama	Preproduction	5,840	223	2011	0.85
Total			**123,589**	**3,096**		

Source: National Trust

4. Global Copper Demand Analysis

4.1 Copper Demand by Product and Country

As large developing countries have gradually entered the global market, demand for mineral commodities, including copper, has increased.

Table IV- 7: World refined copper demand ('000 tons)

	2004	2005	2006	2007	2008	2009	2010	2011e	2012e	2013e	2014e
Western Europe consumption	3,797	3,574	3,936	3,667	3,433	2,839	3,125	3,203	3,235	3,251	3,267
percentage change	*2.2%*	*-5.9%*	*10.1%*	*-6.8%*	*-6.4%*	*-17.3%*	*10.1%*	*2.5%*	*1.0%*	*0.5%*	*0.5%*
US consumption	2,712	2,549	2,395	2,304	2,185	1,773	1,892	1,930	1,949	1,959	1,969
percentage change	*8.6%*	*-6.0%*	*-6.0%*	*-3.8%*	*-5.2%*	*-18.9%*	*6.7%*	*2.0%*	*1.0%*	*0.5%*	*0.5%*
China consumption	3,565	3,815	3,967	4,670	5,100	6,375	7,204	7,672	8,171	8,661	9,181
percentage change	*18%*	*7.0%*	*4.0%*	*17.7%*	*9.2%*	*25.0%*	*13.0%*	*6.5%*	*6.5%*	*6.0%*	*6.0%*
Japan consumption	1,279	1,256	1,307	1,268	1,199	876	1,060	1,028	1,069	1,091	1,102
percentage change	*6.3%*	*-1.8%*	*4.1%*	*-3.0%*	*-5.4%*	*-26.9%*	*21.0%*	*-3.0%*	*4.0%*	*2.1%*	*1.0%*
Other consumption	5,663	5,739	5,831	6,053	6,124	5,543	5,960	6,366	6,597	6,843	7,048
percentage change	*10.3%*	*1.3%*	*1.6%*	*3.8%*	*1.2%*	*-9.5%*	*7.5%*	*6.8%*	*3.6%*	*3.7%*	*3.0%*
Refined copper consumption	17,016	16,933	17,436	17,962	18,041	17,406	19,241	20,199	21,021	21,805	22,567
percentage change	*9.3%*	*-0.5%*	*3.0%*	*3.0%*	*0.4%*	*-3.5%*	*10.5%*	*5.0%*	*4.1%*	*3.7%*	*3.5%*

Note: 2011-2014 are forecasted data
Source: JP Morgan Commodity Research

Chinese consumption is growing rapidly and the country is now the world's top consumer, reflecting its continued modernization and infrastructure development and strong expectations for economic and manufacturing sector growth. The US, a traditional major copper consumer, now consumes less than half of the Chinese consumption. Japan, Poland, Mexico, Russian, Canada, Australia and Indonesia, the major copper producers or refiners in the world, are also major copper consumers. Chile, however, the biggest mine producer, consumes only about 100,000 tons per year.

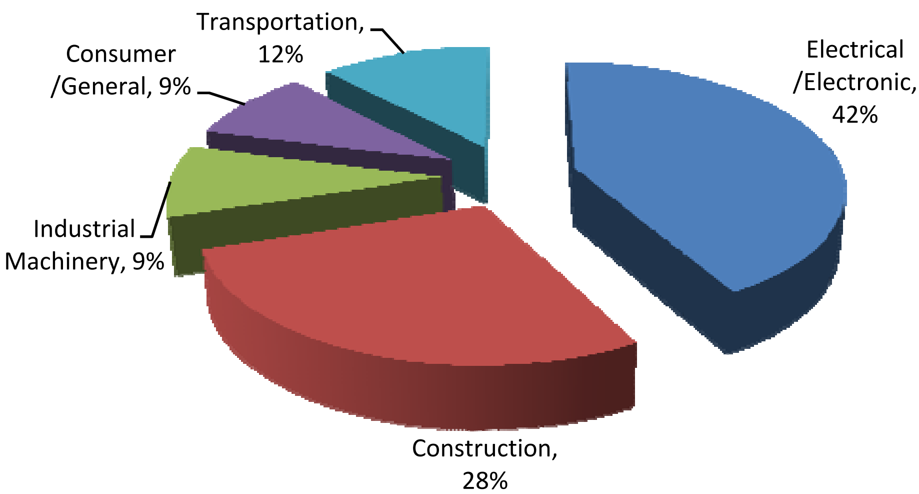
Table IV- 8: World copper consumption by major countries ('000 tons)

Countries/Year	2002	2003	2004	2005	2006	2007	2008
China	2,737	3,084	3,364	3,656	3,610	4,861	4,817
United States	2,364	2,290	2,410	2,270	2,128	2,170	1,992
Japan	1,164	1,202	1,279	1,229	1,282	1,252	1,254
Poland	247	253	274	274	269	299	301
Mexico	383	353	394	402	335	299	335
Russia	355	422	550	667	693	687	770
Canada	271	256	347	291	302	206	164
Australia	189	184	169	158	144	147	134
Indonesia	109	121	188	180	185	205	222
Chile	81	96	99	103	111	105	n/a
Peru	55	55	55	55	55	55	n/a
Others	9,833	10,085	10,899	11,003	11,484	12,539	13,072
Total	**15,051**	**15,317**	**16,664**	**16,632**	**16,988**	**17,964**	**18,244**

Source: The Australian Bureau of Agricultural and Resource Economics, CRU

Copper is mainly used in the electrical, construction, industrial machinery and transportation industries.

Figure IV- 4: Copper consumption by industry



Source: Standard CIB Global Research

Electrical industry: The electrical properties of copper are exploited in copper wires and devices such as electromagnets. The largest use of copper is in the power utilities market. Integrated circuits and printed circuit boards increasingly feature copper in place of aluminum because of its superior electrical conductivity, and heat sinks and heat exchangers use copper as a result of its superior heat dissipation capacity. Vacuum tubes, cathode ray tubes and the magnetrons in microwave ovens also use copper. The four market segments that make up this market are power utilities, telecommunications, business electronics and lighting & wiring devices.

Construction industry: Copper's second largest usage is in the construction industry. The waterproof nature of copper has lent itself for use in roofing material since ancient times. The copper used is phosphorus deoxidized copper, which is highly corrosion-resistant. Lightning rods use copper as a means to divert electric current to the ground to avoid destroying the main structure. Copper has excellent brazing and soldering properties and can be welded. Building construction comprises the following market segments: building wiring, plumbing and heating, air conditioning and refrigeration, builders' hardware and architectural.

Industrial machinery industry: Copper can be found almost everywhere in industrial machinery, because copper alloy axletrees are needed to connect different machinery parts. Copper alloy, with its high strength, good electrical conductivity and thermal conductivity, is the most widely used material in various devices and appliances. The industrial machinery consumption for copper is more than 1 million tons per year.

Transportation industry: This is the fastest growing market, comprising the following five market segments: automobiles, railroad, trucks and buses, aircraft and aerospace, and marine.

4.2 Trends in Demand

From the following three figures, we can see the areas with the fastest growth in copper consumption are changing. Since 2000, North American and Australian consumption of copper has been declining, while Russian and Chinese consumption has growing robustly. This trend is expected to continue until at least 2020.

Figure IV- 5: Distribution of copper consumption growth in the 1980s

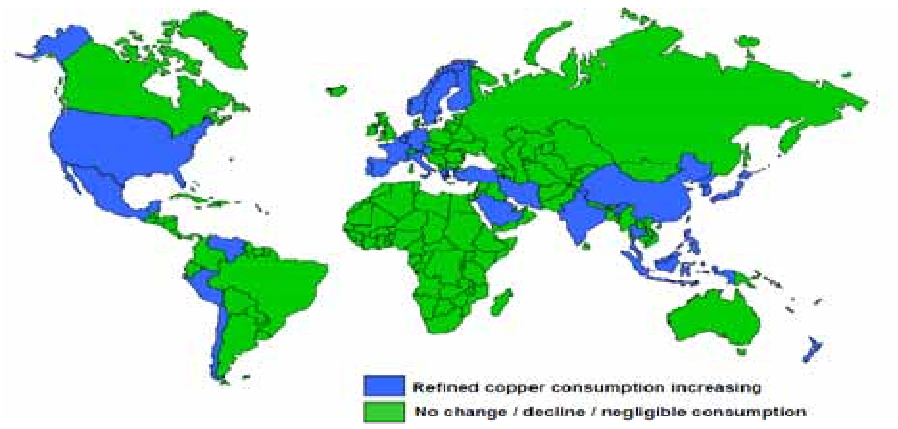


Figure IV- 6: Distribution of copper consumption growth in the 1990s

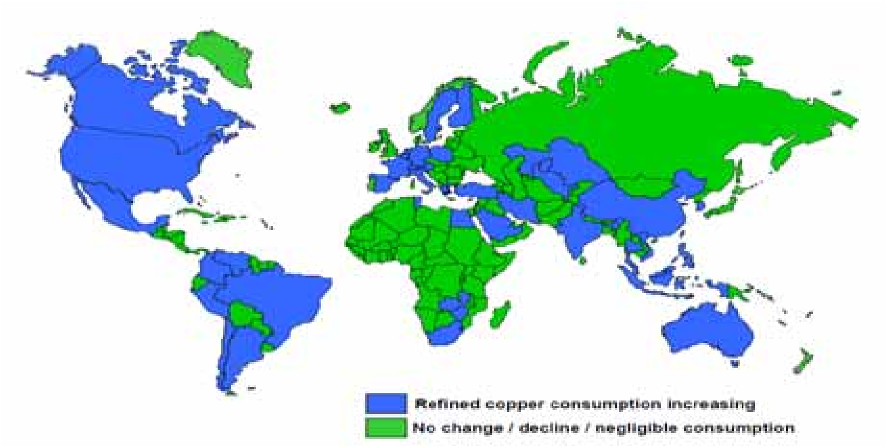
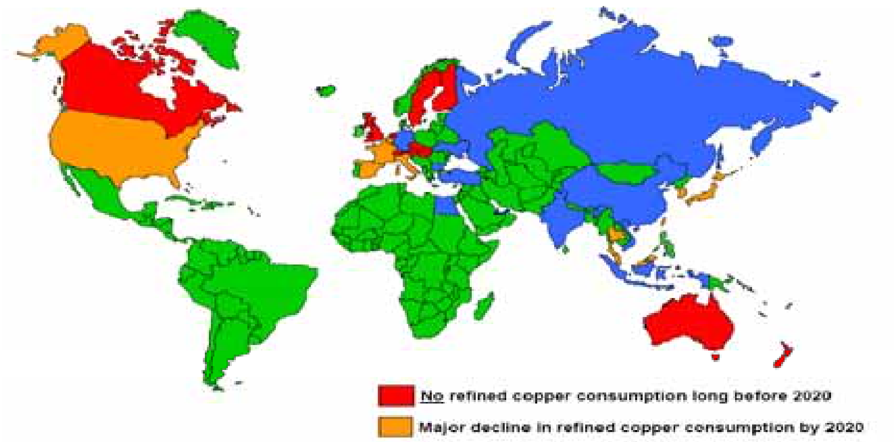


Figure IV- 7: Distribution of copper consumption growth, 2000-2020



Source: CRU analysis

According to Reuters, total global demand growth for copper is expected to drop to 8.4% in 2011-12, a substantial slowdown from the average growth of 16.4% between 2005 and 2010.

Copper consumption growth is expected to be in the following product segments and countries.

Table IV- 9: Copper consumption growth segments and countries

Product segments	New capacity investment hotspots
Wire and rod	China, United Arab Emirates, Saudi Arabia, Egypt, Turkey, Spain, Russia, Bulgaria
Sheet and strip	China, India, Bulgaria, Japan
Tube and pipe	China, Mexico, USA, Iran, Thailand, Vietnam
Rod and bar	China, Bulgaria

Source: CRU analysis

4.3 Demand Drivers and Expected Changes in Demand

Economic growth is the major copper demand driver. The demand for copper dropped in 2009 due to the financial crisis; however, as the economy recovers, demand has also risen.

China, as the country with the fastest growth rate, has played an especially important role in driving up copper consumption since 2002.

5. China Dynamics

5.1 Demand/Supply Balance and Trends

China is one of major copper consumers in the world and has been the top consumer of copper since 2002. Moreover, China's domestic copper production cannot satisfy its demand and the country is a net importer of copper resources. It can be expected that China will exert much more significant influence on the worldwide copper market with further economic growth. China's rapid economic growth is not, however, the sole reason for its increasing reliance on imports; the reduction of newly discovered reserves is another big factor.

Developed copper mines in China are mainly located in the eastern, middle and southern parts of China, where geographic conditions are better, the economy is more developed, and exploration work is more concentrated. In these areas, copper mines form seven major copper bases including Jiangxi, Tongxing, Daye, Baiyin, Zhongtiaoshan, Yunnan and northeast bases.

Table IV- 10: Major copper producers in China

Companies	Description	Production Capacity
Jiangxi Copper Corporation (JCC)	Established in 1979 in Jiangxi province and listed in 2008, JCC is now the largest copper producer and fabricator in China and a top 3 cathode producer in the world; runs 8 mines, 3 smelters and 6 copper fabrication companies.	Cathode capacity 950,000 t/y
Tongling Nonferrous Metals Group Co., Ltd.	Located in Anhui province and listed in 1996, the company's main business is copper mining, smelting and refining; the second largest cathode producer in China and fifth largest copper concentrate company in the world.	Cathode capacity 900,000 t/y
Yunnan Copper Co., Ltd.	Founded in 1958 in Yunnan province; the 18th largest copper producer in the world and 3rd largest copper producer in China; products including copper cathode, copper rod and bare copper wire; Aluminium Corporation of China acquired 49% of the company in 2007.	Cathode capacity 650,000 t/y
Daye Nonferrous Metals Co., Ltd	Founded in 1953; one of the five large copper bases in China; main businesses including mining, smelting, casting, processing and trading of gold, silver, copper, iron and aluminum.	Cathode capacity 400,000 t/y
Jinchuan Group Ltd.	Located in Ganshu province, a large integrated nonferrous metallurgical and chemical engineering enterprise; engaged in mining, concentrating, metallurgy and chemical engineering; owning copper reserves of 3,430,000 tons, the second largest in China.	Cathode capacity 400,000 t/y
Xiangguang Copper Co., Ltd.	Located in Shandong province; a large-scale nonferrous smelter.	Cathode capacity 400,000 t/y
Baiyin Nonferrous Metal (Group) Co., Ltd.	Established in 1954; the oldest copper and sulphur producer.	Cathode capacity 200,000 t/y
Zhongtiaoshan Nonferrous Metals Group Co., Ltd.	Established in 1956 and located in Shanxi province; mainly dealing with copper exploring, dressing, smelting and processing.	Cathode capacity 100,000 t/y

Source: Somerley

From 2002 to 2008, copper concentrate production in China grew from 1,580,000 tons to 3,696,000 tons, an increase of 133.9%. However, after many years of exploitation, most mines are entering into the mid- or late life, and are confronting different degrees of resource crisis.

China became the largest copper concentrate importer in 2001 and, since then, has consolidated its position as the biggest consumer. In 2002, China consumed 2,500,000 tons of copper concentrate but produced only 1,580,000 tons, yielding a gap between consumption and production of 1,000,000 tons, or about 40% of the total consumption. In 2008, Chinese copper consumption reached 4,817,000 tons, accounting for 26.4% of the world consumption. From 2002 to 2008, the annual consumption growth rate was 16.7%.

According to a National Trust research report, copper consumption in China in the electricity industry accounts for 53% of total consumption, while consumption in home appliances, including conditioners and refrigerators, accounts for about 10%. The real estate and automobile industries also consume large quantities of copper.

The same research report indicates that China's average copper consumption should increase as GDP per capita increases. With GDP per capita under USD 15,000, average refined copper consumption is about 4 kg; when the GDP per capital rises above USD 30,000, average copper consumption could rise significantly. Therefore, China still has great potential for growth in copper consumption.

Table IV- 11: China's copper concentrate supply/demand balance, 2003 – 2008 ('000 tons)

Items/Year	2003	2004	2005	2006	2007	2008
Production (1)	1,772	2,061	2,543	2,999	3,497	3,696
Net import (2)	1,293	1,110	1,077	584	1,368	2,017
Supply (3)=(1)+(2)	3,065	3,171	3,620	3,583	4,865	5,713
Consumption (4)	3,031	3,205	3,628	3,800	4,562	4,817
Supply/consumption balance (5)=(3)/(4)	34	-34	-8	-217	303	896
Reliance on import (6)=(2)/(3)	42.2%	35.0%	29.7%	16.3%	28.1%	35.3%

Source: Antaike, CRU

5.2 China's Policy

Beginning in 2005, the Chinese government started to strengthen its macro control over the copper industry.

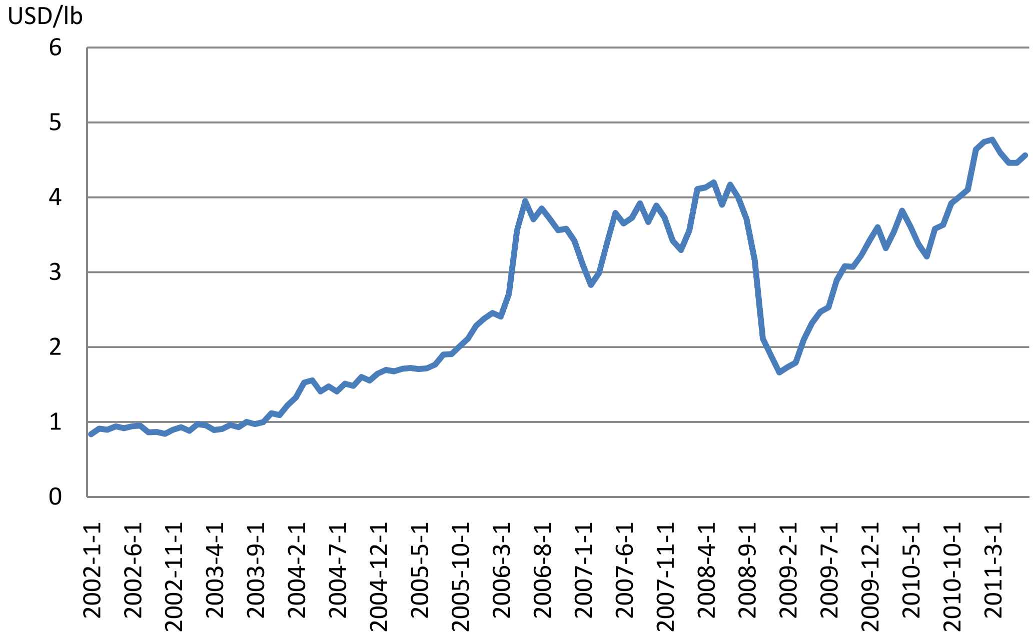
First, the government started to overhaul the copper smelting projects and improve the industry access system. Registered copper smelting projects that had a capacity of less than 100,000 t/y, that didn't use new energy-saving technology, or that used less than 25% raw material from their own mines were to be stopped.

Second, the export policy became increasingly restrictive. In 2005, China increased the export tax rate of refined copper from 0 to 5%, then to 10%, and finally to 15%. The government also eliminated the export VAT rebate for refined copper, copper alloy and copper powder, and decreased the export VAT rebate rate for copper fabrication products from 15% to 13%. With a series of restricted policies, the government aimed to restrain copper export and first satisfy the domestic demand.

6. Pricing

As a major industrial metal, the price of copper closely relates to the global economy. Copper prices rose four-fold from 2002 to 2007, driven by strong global growth. However, during the financial crisis of 2008-09, a majority of these price gains was given up. However, prices have rebounded since to pre-financial crisis levels, driven by strong demand from emerging markets, especially China.

Figure IV- 8: Historical copper price (USD/lb)



Source: lapptannehill.com