

Manganese 101

■ Manganese Geology

Manganese occurs principally as manganese oxide (pyrolusite (MnO₂)). Globally, manganese ore with a grade of circa 44% Mn is considered high grade. Primary high grade resources are located in South Africa, Gabon and Australia. China, an important manganese end market, is a low grade (20-30%) manganese ore producer.

■ Mining to milling

Manganese is usually mined from open-pit operations. Manganese ore is treated to produce manganese ore concentrate. The concentrate is further processed to produce manganese alloys or pure manganese metal.

■ Uses of manganese

Manganese is primarily used in the making of steel, which accounts for approximately 85-90% of total manganese demand. Other than in steelmaking, manganese is also important for the chemicals industry in the production of lithium and dry cell batteries, fertilizers, pigments etc.

■ Manganese fortunes depend on steel production forecasts

The steel sector accounts for the major portion of manganese demand and fundamentals of manganese depend to a large extent on the outlook for steel production.

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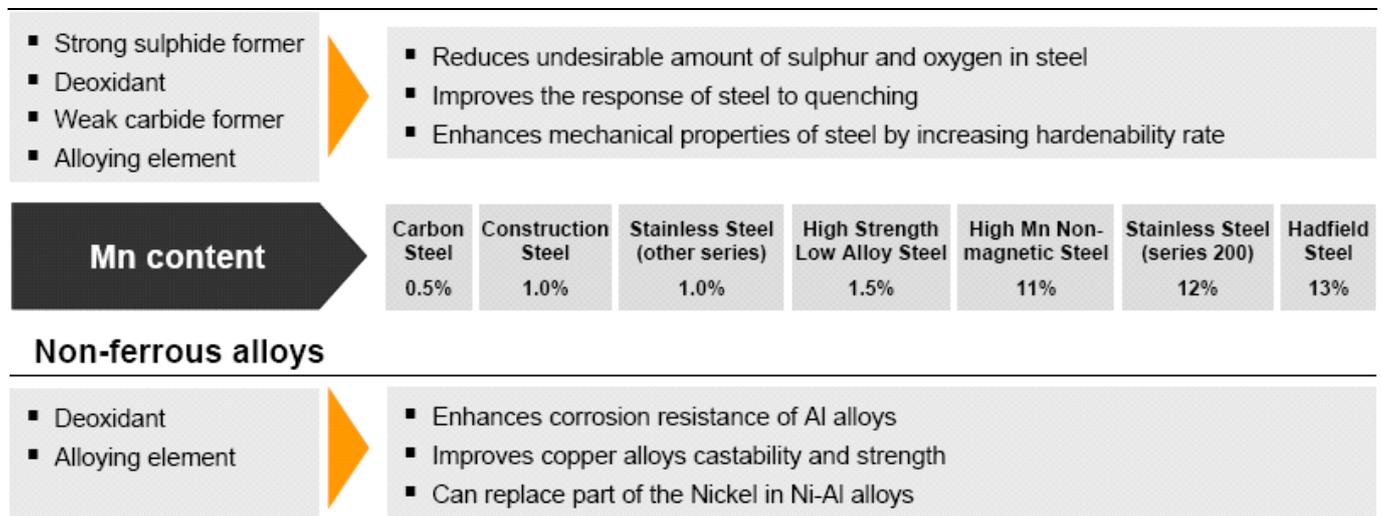
Manganese Uses

Manganese is primarily used in the making of steel, which accounts for approximately 85-90% of total manganese demand. High-grade manganese ore reduces alloying costs by facilitating the reduction process in steel making and decreasing coke consumption. The two forms of manganese that are widely used in steel production are ferro-manganese and silico-manganese. Manganese plays the following important roles in steelmaking:

- Increases hardness, toughness as an alloying element
- Improves tensile strength
- Combines with and removes sulphur from iron
- Assists in producing fluid slag
- Acts as a deoxidiser

Manganese has no direct substitute as such and the intensity of the use of the metal (consumption of the metal per unit of steel produced) varies across regions, which is an important factor in determining the demand of the metal. The proportion of manganese in steel can vary from 0.05% to 2% and up to 10% in some cases. Advanced steelmaking technology has resulted in falling manganese consumption per unit of steel produced with the current average consumption expected to be around 9-10kg/t for carbon steel.

Chart 1: Manganese applications in ferrous and non-ferrous alloys



Source: ENRC presentation

Other than in steelmaking, manganese is also important for the chemicals industry in the production of lithium and dry cell batteries, fertilizers, pigments etc. As a bactericidal, it is used in purifying drinking water, treating waste water and odour control. Manganese is also used in controlling crop and cereal diseases.

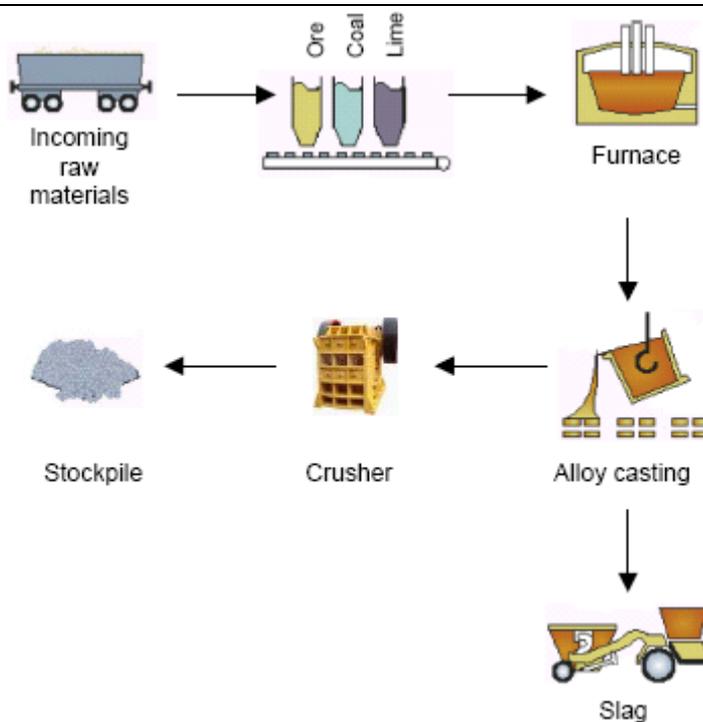
Manganese Geology

Manganese occurs principally as pyrolusite (MnO_2), braunite, $(Mn_2+Mn_3+6)(SiO_{12})$, [4] psilomelane $(Ba,H_2O)_2Mn_5O_{10}$, and to a lesser extent as rhodochrosite ($MnCO_3$). Over 80% of the known world manganese resources are found in South Africa and Ukraine. Manganese ore with 44% grade Mn is considered high grade manganese ore.

Mining to marketing

After being mined, manganese ore is further processed to produce manganese alloys or pure manganese metal. Figure 2 below shows the process to make ferro-manganese. Manganese ore is mixed with iron ore, coke and lime and then reduced in a blast furnace or an electric arc furnace. Ferro-manganese, so produced, has a manganese content of 50%-80% manganese.

Figure 1: Manganese alloy production flow chart



Source: ENRC presentation

Production of pure manganese metal

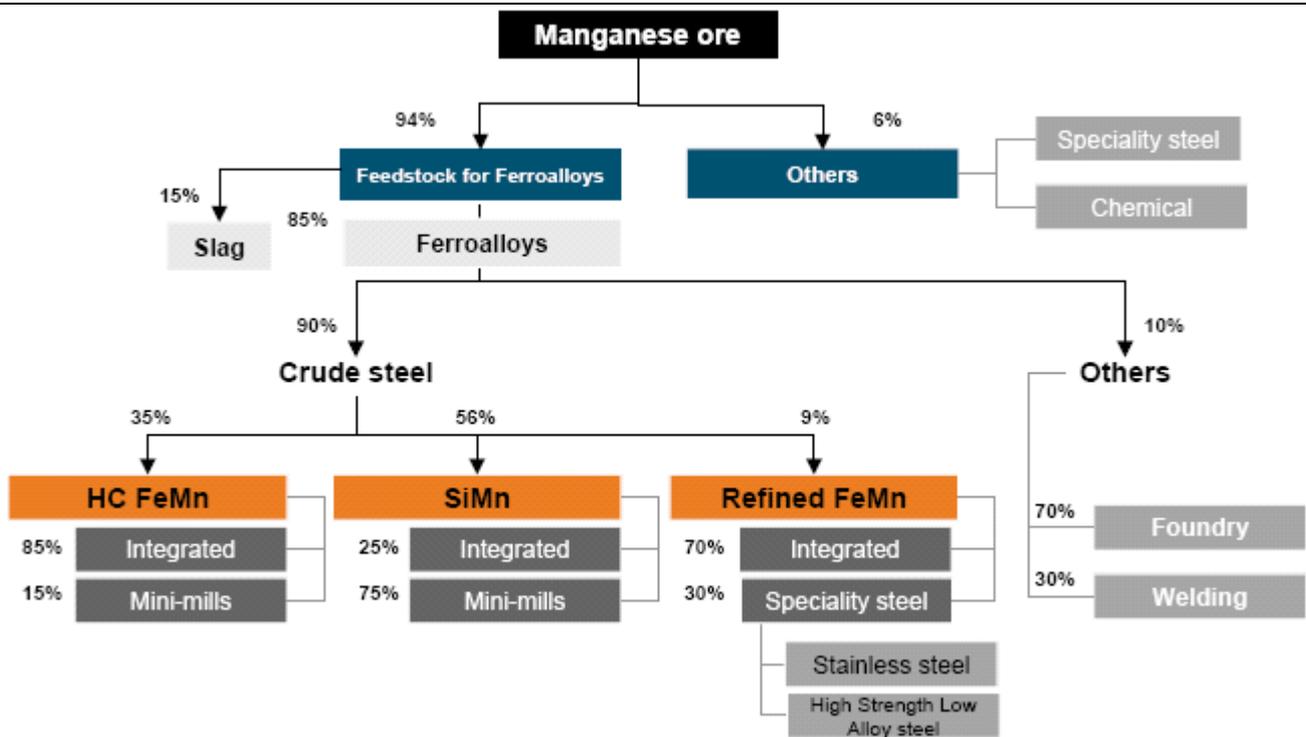
The manganese ore is milled to a powder and then it is reduced to a soluble form in rotary kilns. The reduced ore is dissolved in acid solution, followed by purification (precipitation of impurities and filtration). Sulphur dioxide is added to the purified solution before electrolysis can take place. The process causes manganese to plate on the cathodes while sulphuric acid, formed at the anodes, is re-cycled back to the dissolution process. This manganese stripped from the cathodes is manganese in its purest, cleanest form. Depending on individual customer requirements, the metal is then processed further and packaged for shipment.

Marketing

More than 90% of all manganese ore is used as a feedstock for ferro-alloy and approximately 90% of manganese ferro-alloy finally finds its usage in steel making. Companies can sell manganese ore concentrate and if the company is vertically integrated, it can process the ore and the concentrate to produce and market manganese alloy. As shown in the chart below SiMn has more usage than the other two and accounts for 56% of the global output of manganese alloys.

SiMn (Mn 57-75%) is used as deoxidization and alloying agent, HC FeMn (Mn 70-82%) is used in manufacturing normal and high-carbon steel and Refined FeMn (Mn 75-85%) is used in manufacturing stainless steel, heat resistant steel etc. As per an ENRC presentation, on an average c.9.71kg of manganese alloy is used in making one tonne of steel with SiMn accounting for 5.44kg, High Carbon FeMn 3.34kg and the rest Refined FeMn. Manganese alloy used per tonne of steel tends to vary across region with Europe accounting for as low as 8.51kg per tonne of steel and China for more than 10.5kg per tonne.

Chart 2: Manganese market materials flow

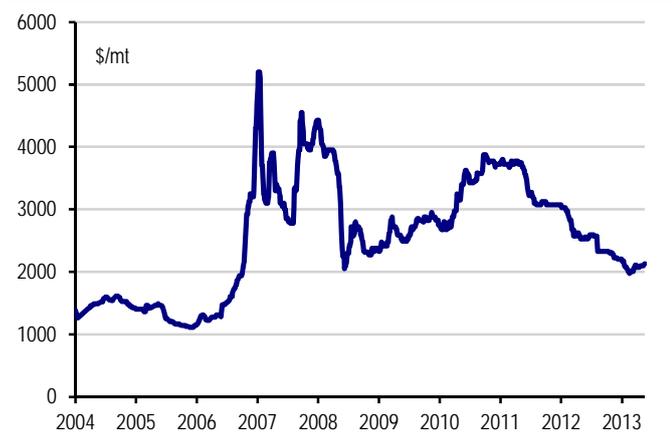


Source: Roskill, ENRC

Pricing

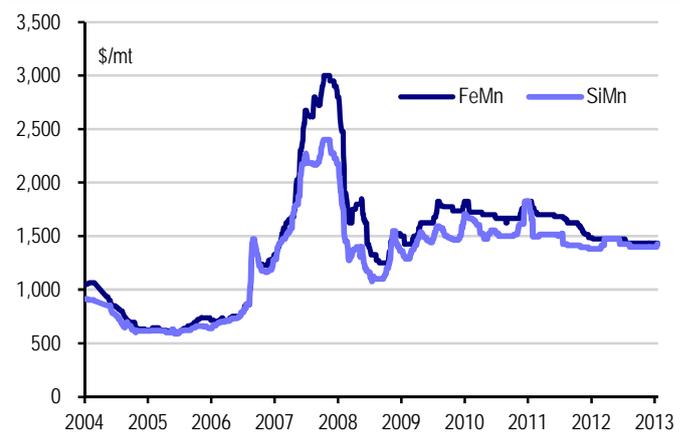
Historically, manganese ore was contracted on annual pricing but has moved to quarterly pricing in the last few years. The charts below show historical manganese ore and ferro-alloy prices. Manganese contract pricing is based on 48% Australian manganese ore FOB, whereas spot pricing is based on 45% Chinese manganese ore on a CIF basis. China is a key driver of the ores prices, in part due to the regions huge steelmaking capacity.

Chart 3: Manganese prices



Source: Metal pages; Manganese flake min 99.7% FOB P.R.C.

Chart 4: FeMn and SiMn monthly prices

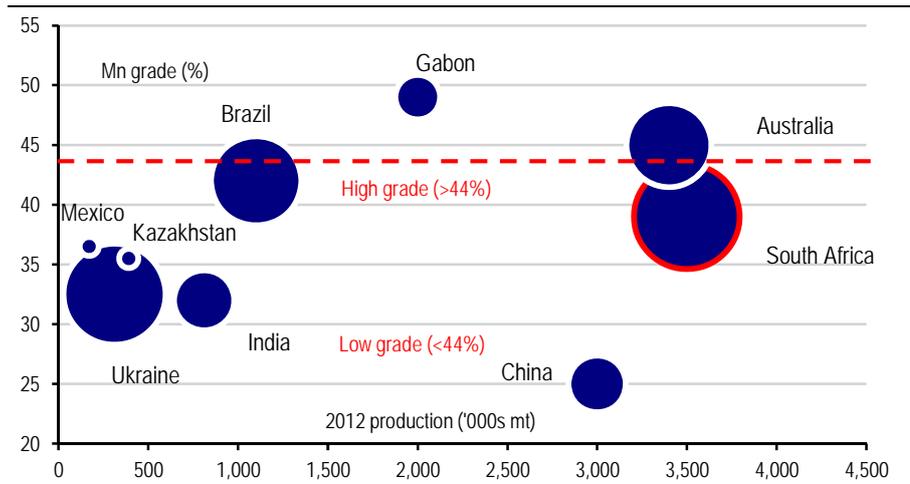


Source: Metal pages; Ferro-manganese 75% HC FOB China (CN); Silico-manganese 65/17 FOB China (CN)

Manganese supply and demand

South Africa, Ukraine, Brazil and Australia hold some of the largest manganese reserves in the world. Chart 9 below shows the world's manganese ore reserves, grades and producers.

Chart 5: World manganese ore reserves, grades and producers



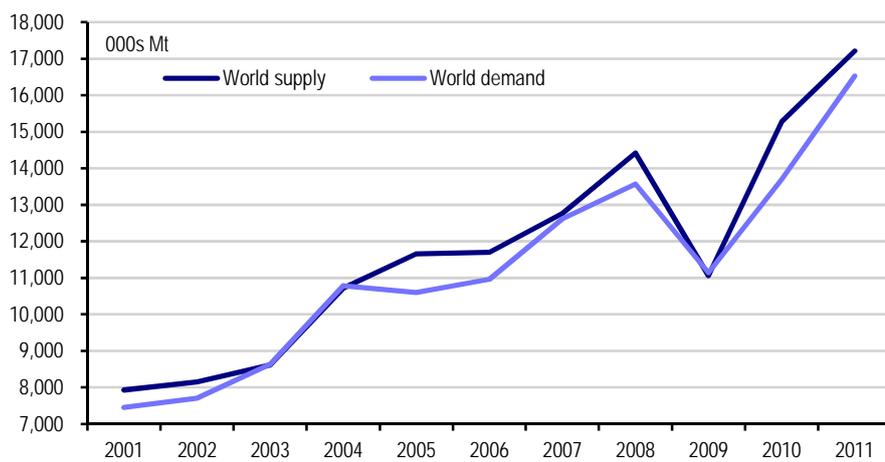
Source: USGS, UBS (bubble size represents total reserves, grade is based on the average of the historical range of Mn content)

South Africa is the largest producer of manganese ore followed by Australia and China. However, the grades produced by China are low as shown in the graph above. The top producers of high grade manganese are Australia, South Africa, Gabon and Brazil.

Some of the largest producing entities of manganese are the JV's between BHPB (60%) and Anglo American (40%), CVRD, Eramet Group, Ghana Manganese company (GMC) and the State of Gabon.

Consolidated Minerals, OM Holdings, and the JV between BHPB and Anglo American are some of the notable Australian manganese producers.

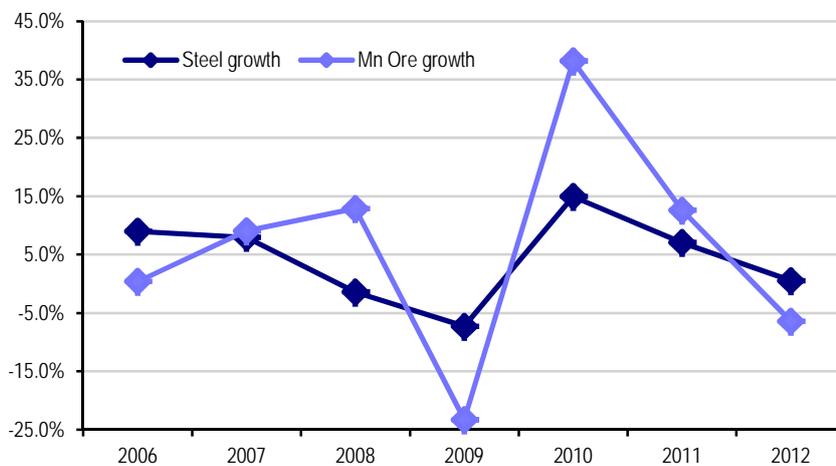
Chart 6: Manganese demand supply balance



Source: IMnI

Manganese demand is almost entirely dependent on steel industry. The chart below shows the growth of the steel vis-à-vis Mn ore. We note steel producers across the globe e.g. China Steel, Posco, Nippon Steel, Bluescope Steel, Thyssenkrupp, Arcelor Mittal etc. have begun to turn blast furnaces back on in response to demand in particular from the automotive industry as well as to rebuild/maintain inventory levels. Increasing steel production is positive for manganese.

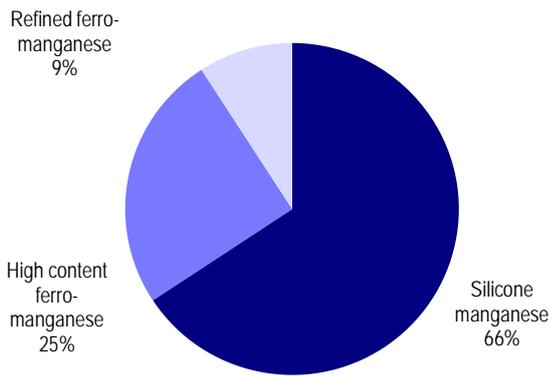
Chart 7: Growth in Steel and Mn Ore production



Source: IMnI

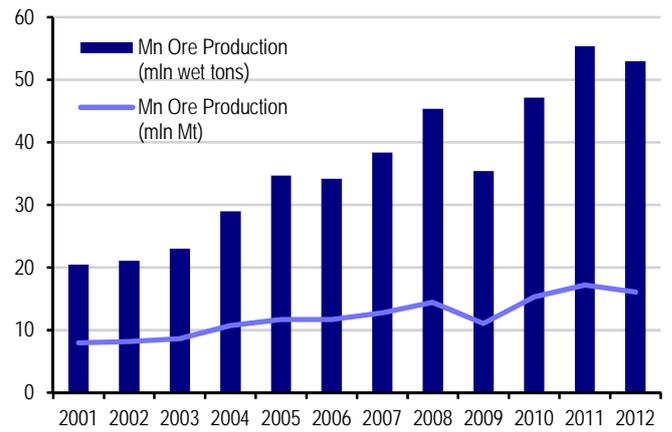
Total manganese alloy production in 2012 was 17.5Mt indicating a decline of 2% y-o-y. Production of manganese ore declined 5% to 16Mt in 2012. According to IMnI, production in wet metric tonnes declined only 4% implying an increase in the share of lower grade ores. The average grade in 2012 was 31%Mn.

Chart 8: Mn alloy by production type, 2012



Source: IMnI

Chart 9: Mn ore production



Source: IMnI

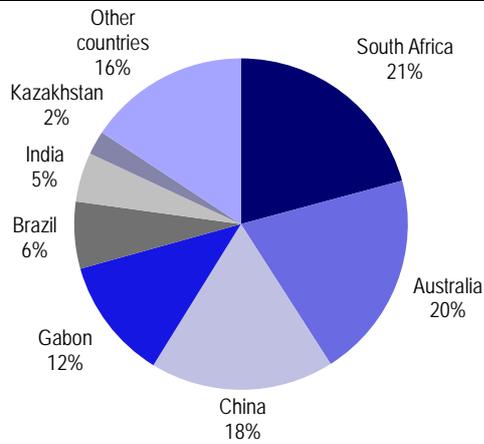
Investment View

Steel sector accounts for the major portion of manganese demand and fundamentals of manganese depend to a large extent on the outlook of steel production. We also note that many steel companies in the past have formed joint ventures or have bought manganese companies in a bid to backward integrate.

Manganese Industry

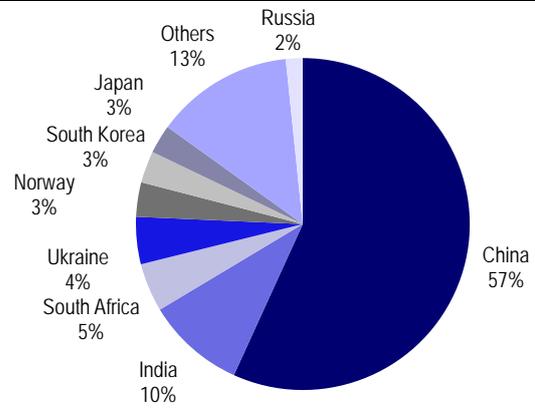
The charts below show the major end users and producers of manganese and the also the major regions in terms of demand and supply of the metal.

Chart 10: Mn ore production by region, 2012



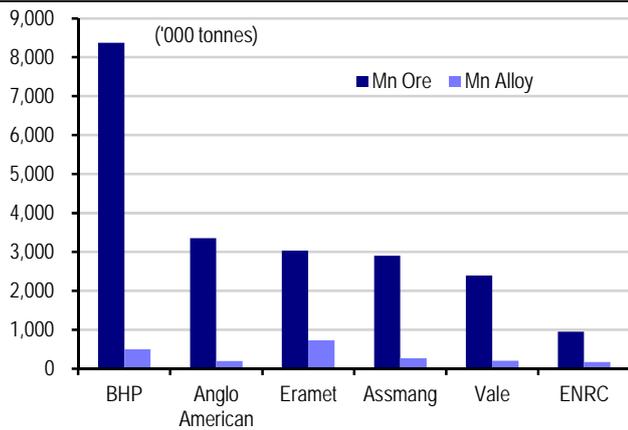
Source: USGS, UBS

Chart 11: Major producers of Mn alloy, 2011



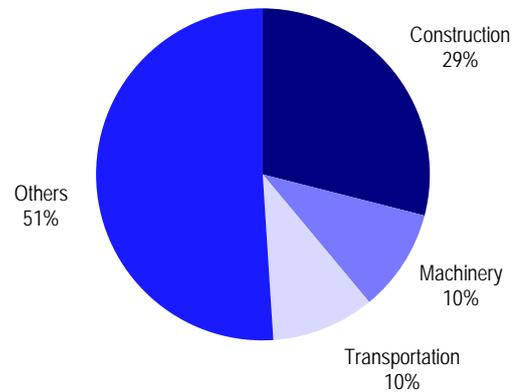
Source: IMnI, UBS

Chart 12: Major producers of Mn ore and alloy, 2012



Source: UBS

Chart 13: End use of Manganese by industry



Source: USGS