

# OVERVIEW OF THE NICKEL INDUSTRY IN SOUTH AFRICA, 1997 – 2006

DIRECTORATE: MINERAL ECONOMICS



**mineral resources**

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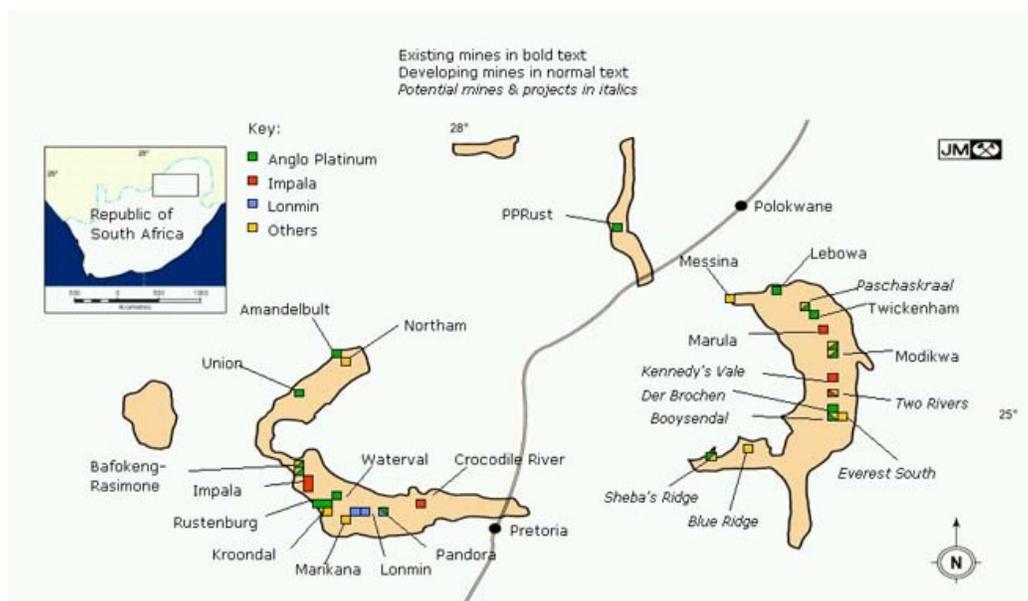
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## 1. Introduction

Nickel (Ni) is the fifth most common element on earth. It is a transition element that exhibits both ferrous and non-ferrous properties. The metal plays a significant role in modern day metallurgical practice due to its exceptional ability to impart properties such as corrosion and heat resistance, strength as well as the formation of alloys with other metals.

Geologically, Nickel occurs in the form of sulphides and laterite minerals. The principal ore minerals of laterites are nickeliferous limonite:  $(\text{Fe, Ni})\text{O}(\text{OH})$  and garnirite (a hydrous nickel silicate):  $(\text{Ni, Mg})_3\text{Si}_2\text{O}_5(\text{OH})$  which accounts for 60 percent of global reserve base and, the balance is in the form of magmatic sulphide deposits where the principal ore mineral is pentlandite:  $(\text{Ni, Fe})_9\text{S}_8$ .

Main sulphide deposits occur in Australia, Canada, Russia and South Africa and involve underground mining whereas laterite deposits are located in Western Australia, Indonesia, Cuba, Colombia, New Caledonia, Venezuela, Brazil and Dominican Republic and are mainly mined in open pit operations.

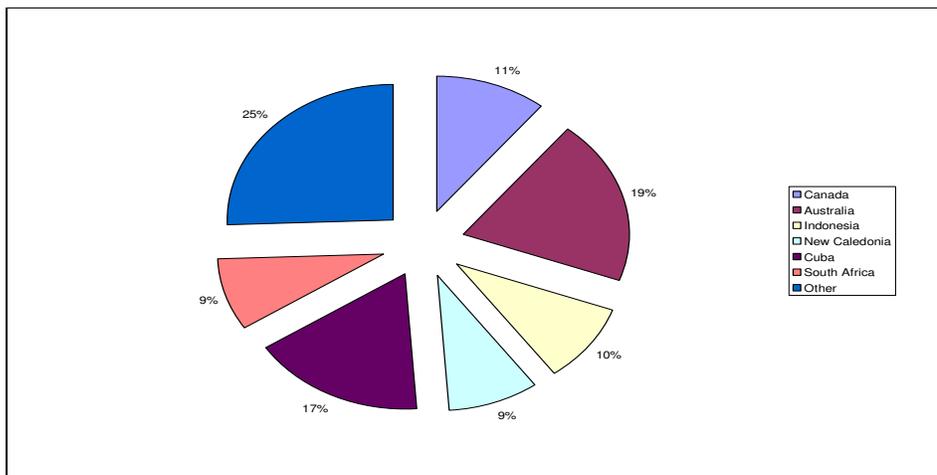


**Figure 1: Schematic map of the Bushveld Complex**

Source: [www.platinum.matthey.com](http://www.platinum.matthey.com)

In South Africa, sulphide deposits are associated with stratiform platinum-bearing reefs in basic and ultrabasic rocks of the Bushveld complex in the North West and Limpopo Provinces (Fig 1), where it is extracted as a by-product in platinum group metals (PGM) mining. The Bushveld complex stretches from Rustenburg in the west to Lydenburg in the east, and from Pretoria in the south to Polokwane in the north. Nickel deposits are located together with platinoid minerals found in all reefs with nickel content, the highest in the Plat reef followed by the Merensky reef and the lowest in the UG2 chromatite reef. The nickel bearing horizon occurs over a total length of approximately 250 kilometers. In the Mpumalanga province, nickel occurs in a number of distinct zones within the Uitkomst Complex as a layered sequence of mafic-ultramafic intrusion rocks hosting four sulphide zones containing nickel, cobalt, copper and PGM.

In 2007, world nickel reserve base was 137, 1 Mt and with major country distribution by Australia and Cuba contributing 19 percent and 17 percent respectively (Fig. 2). South Africa was ranked 5<sup>th</sup> with ~12, 0 Mt nickel reserves representing 9 percent of the world's nickel reserves.



**Figure 2: World Nickel reserves**

Source: SAMI 2006

## **2. Nickel Processing**

Nickel can be recovered using extractive metallurgy, where the deposits are initially concentrated through froth flotation process and subsequently subjected to the pyrometallurgical process. In the latter process, nickel concentrate is roasted followed by reduction to yield a metal of >75 percent purity. This metal is further purified to >99,9 percent using the Mond process. Nickel is reacted with carbon monoxide to form volatile nickel carbonyl which is passed into a large chamber at high temperatures in which nickel spheres are maintained in constant motion. At this stage, nickel carbonyl decomposes pure nickel into nickel pellets. Alternatively, the nickel carbonyl may be decomposed in a smaller chamber to create a fine powder. The highly pure nickel produced by this process is known as carbonyl nickel. In many stainless steel applications, nickel can be taken directly in the 75 percent purity form depending on the presence of impurities.

Nickel sulphide ores undergo flotation (differential flotation if Ni/Fe ratio is too low) and then, get smelted. Smelting a nickel sulfide flotation concentrate requires Magnesium Oxide level of less than 6 percent, otherwise, the temperature at which the smelting will be run will be too high and lead to higher operating costs. After producing the nickel matte, further processing is done via the Sherrit-Gowden process. The first stage involves the removal of copper by adding hydrogen sulfide, leaving a concentrate of only cobalt and nickel. Solvent extraction employed to the concentrate separates the cobalt and nickel, achieving the final nickel concentrate of more than 99 percent purity.

## **3. Applications**

The use of nickel is traced as far back as 3500 BC, where it was used in superior weapons and household utensils. Today, nickel is used in many industrial and consumer products, which includes stainless steel, magnets, coinage, super alloys plating and as a green tint in glass. Nickel is the finest alloy metal, and is mostly used in nickel steels and nickel cast irons, of which there are numerous varieties. It is also widely used for many other alloys,

such as nickel brasses and bronzes, and alloys with copper, chromium, aluminium, lead, cobalt, silver and gold. Nickel can also be used as a catalyst in the hydrogenation of vegetable oils, the reforming of hydrocarbons and the production of fertilisers, pesticides and fungicides.

Approximately 65 percent of nickel consumed in the western world makes stainless steel. Another 12 percent goes to super alloys, while the remaining 23 percent of consumption is shared between alloy steels, rechargeable batteries, catalysts and other chemicals, coinage, foundry products and plating.

## **4. South Africa's Nickel Industry**

### **4.1 Main Producers**

Nickel production in the past decade has been dominated by Russia followed by Canada, Australia and Indonesia in their order. These countries combined, contributed 56, 3 percent to the total world production in 2006, while South Africa contributed 2, 9 percent.

In South Africa, 21 mines produced nickel in 2006, of which 19 were PGM operations, one from copper mining and one from primary nickel operation and it was ranked 10<sup>th</sup> in terms of output. The largest group of the PGM operations are Anglo Platinum, Impala Platinum and Lonmin.

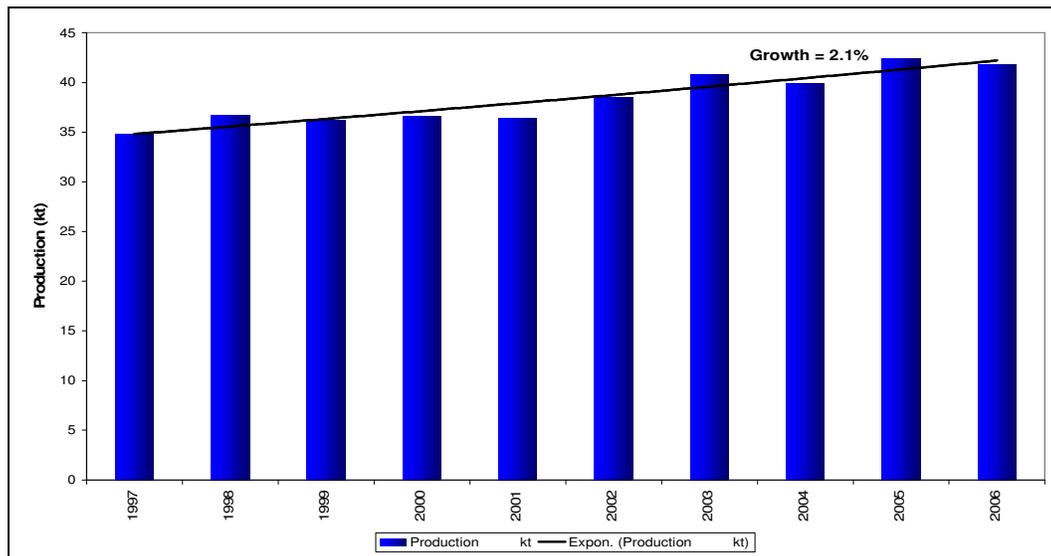
Approximately 87 percent of South Africa's total nickel output is produced from PGM mining operations while 1 percent arises from Palabora copper mining. Primary nickel is mined at only one operation, the Nkomati Nickel, which is small by world standards and accounts for 12 per cent of domestic mine output. Since it was established in 1997, Nkomati Nickel has focused its main operations on a high grade nickel ore body averaging about 2,2 percent nickel that will be largely depleted by 2007. The joint venture between Lion Ore and Nkomati Nickel's owner African Rainbow Minerals (ARM) in 2004 will enable it to mine a considerably lower grade but much larger orebody using Lion Ore's Activox processing technology and thus, increase the life of the mine beyond 2020.

The tracking of South African refined nickel output is more complex due to the movement of various materials, both amongst local producers and as imports and exports, either for further refining or for consumption.

#### 4.2 Production and consumption

Strong economic growth in the past decade has continued to support the rise in nickel production. The nickel industry is driven by the stainless steel market which is highly depended on the global economic condition. On average, nickel has achieved a long term annual growth rate of almost 6 percent since the 1950's to reach nearly 1, 4 Mt in 2006.

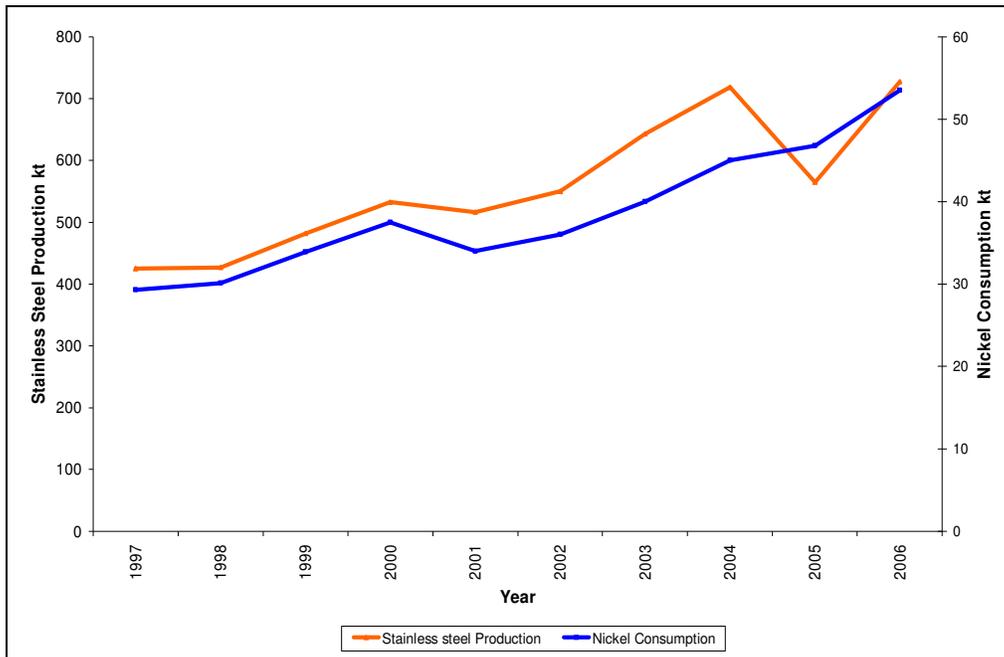
Demand for nickel is driven mainly by stainless steel production. World stainless steel production increased by 16,7% to 27,8Mt in 2006 driven by strong global economic growth. Consequently, global nickel production increase by 3,1 percent to 1,4 Mt in 2006 for 1,05Mt in 1997. Over the period under study, South Africa produced a total of 384,1kt of refined nickel and mine production increased from 34,8kt in 1997 to 41,8kt in 2006 (Fig 3), a 2,1 percent increase.



**Figure 3: South Africa's nickel production growth rate**

Source: Directorate: Minerals Economics

More than 67 percent of nickel is consumed in stainless steel production which is largely driven by industrial growth in the developing countries, particularly China. Local consumption has been growing steadily at 5,7 percent per annum, in line with the local stainless steel growth rate of 6,2 percent per annum since the expansion of Columbus Stainless Steel in 1992 (Fig 4).

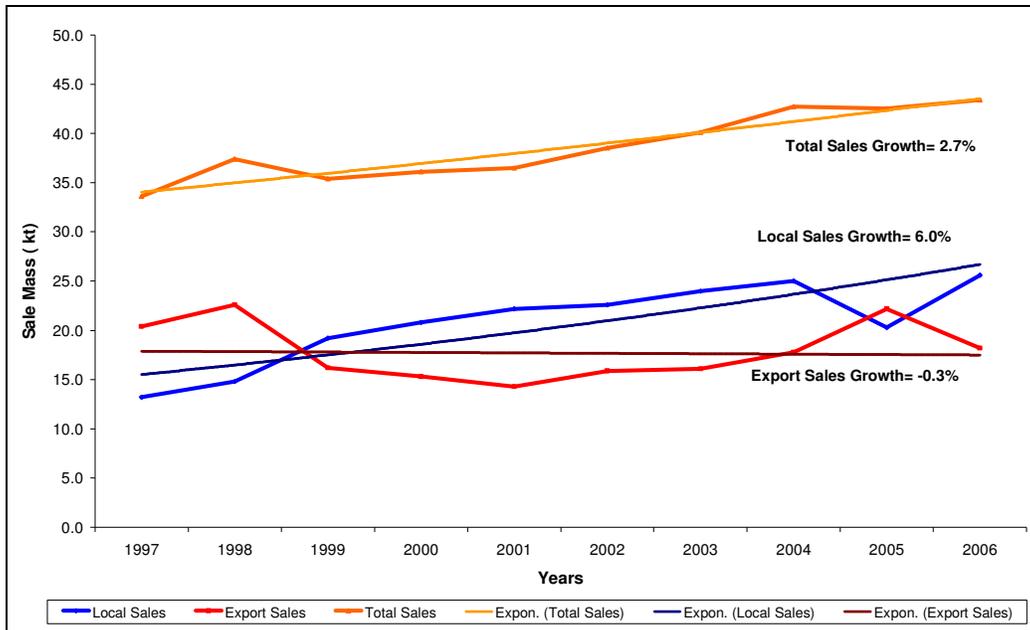


**Figure 4: South Africa's nickel consumption versus stainless steel production**

*Source: World Metal Statistics Yearbook, 2006*

### 4.3 Sales

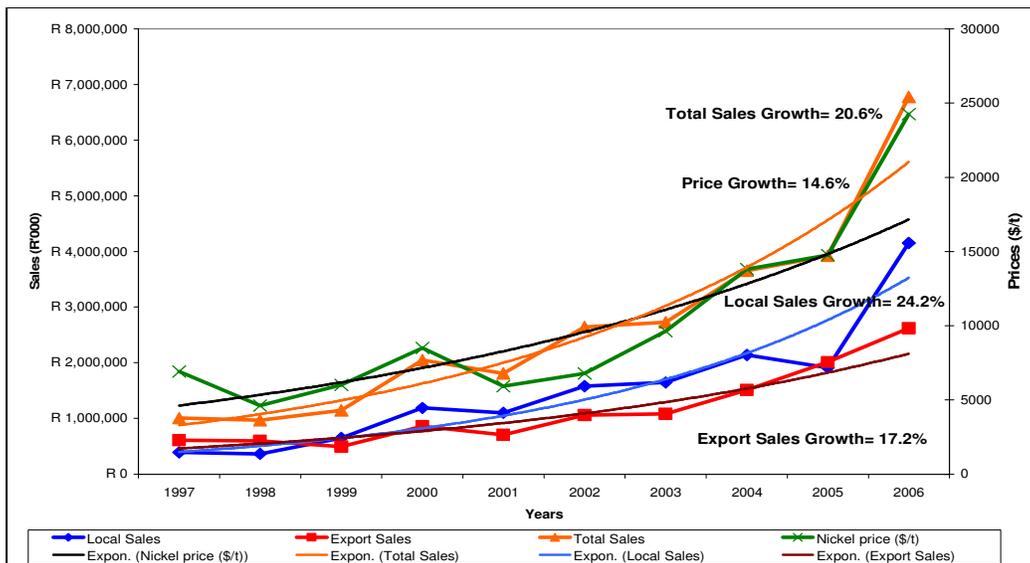
On average, South Africa exports 47 percent of its total output with the remainder being used locally. Over the last decade, local sales mass have almost doubled whereas export sales mass have declined. The 6, 0 percent growth in local sales mass can be attributed to the increasing contribution to South Africa's expanding stainless steel production. Exports sales mass have declined by 0, 3 percent year on year.



**Figure 5: Local, exports and total sales mass growth rates**

Source: Directorate: Minerals Economics

Graphical displays of export revenues of nickel during the period 1997 to 2006 shows the rising importance of this commodity. The 17,2 percent per annum trend over the period under study illustrates the significance of nickel as an important revenue earner.



**Figure 6: Nickel Local, Export, Total Sales and Prices**

Source: Directorate: Mineral Economics and LME

The economic growth from developing countries and the persistent rise in world nickel demand have pushed prices up resulting in a 14,6 percent increase. Total sales grew at a rate of 20,6 percent per annum to R6, 78 billion in 2006 from R1, 00 billion in 1997 due to a combination of record high prices and the systematic weakening of the rand. Export sales revenue grew at an annual average rate of 17,2 percent while local sales grew at a rate of 24,2 percent.

## **5. Threats to the nickel industry**

### **5.1 Nickel substitute**

With a few exceptions, nickel substitutes would result in increased costs or some trade off in the economy or less efficiency in the product performance. In the construction and transportation industries, nickel can be substituted with aluminium, coated steels, and plastics; in power generation, petrochemical, and petroleum industries nickel-free specialty steels can be used; and titanium and plastics in severe corrosive applications.

In recent years, the increasingly high nickel prices and their volatility have raised fears and pushed countries like Japan, China and India towards substituting ferritic stainless steel for austenitic steels which uses manganese-chromite instead of nickel.

### **5.2 Environmental impact**

Certain forms of nickel may have harmful environmental effects including health and safety. Growing concerns on environmental issues have motivated countries and international organisations to regulate the use of metals, including nickel, based on their chemical and physical properties and the harmful effects that their use may cause. In 2003, the European Communities announced a plan to amend chemicals policy under the REACH legislation. REACH is a European Community Regulation on chemicals and their safe use. It deals with the Registration, Evaluation, Authorisation and

Restriction of Chemical substances. The aim of REACH is to improve the protection of human health and the environment through better and earlier identification of the intrinsic properties of chemical substances.

The REACH Regulation gives greater responsibility to industry to manage the risks from chemicals and to provide safety information on the substances. Producers and users are required to gather information on the properties of their chemical substances, which will allow their safe handling, and to register the information in a central database run by the European Chemicals Agency (ECHA) in Helsinki.

The Regulation also calls for the progressive substitution of the most dangerous chemicals when suitable alternatives have been identified. The European Commission have recently proposed that nickel be classified under the dangerous substances directive with consequences that nickel and nickel compounds carry labels indicating that they are serious health risks. REACH can have a very severe impact on exports considering that most of South Africa's minerals are exported to the European Union member states.

## **6. Outlook**

According to the International Nickel Study Group, world primary refined nickel production is estimated to increase to 1,47Mt and 1,57Mt in 2007 and 2008 respectively. The Asian thirst for nickel is not expected to significantly taper off anytime soon, and the demand for stainless steel goods is increasing, world primary nickel consumption is expected to decrease to 1,35Mt in 2007 and increase to 1,47Mt in 2008. The decrease in 2007 is due to Europe, Japan and US's decline in usage although China's usage continues to increase.

South Africa's nickel output is expected to increase in the future, with Nkomati mine's phase 2 expansion project, projected to increase the average annual production of nickel to 20,5kt over 18 years and the estimated 1886kt of nickel resources available in new PGM projects over 30 years.

The high nickel prices spike has impacted on both the supply and demand of the nickel industry. Due to these high prices, many stainless steel producers, representing the largest single demand for nickel, are diversifying, switching more of their output to low nickel or nickel free alternatives such as the introduction of processes to produce nickel-free 400 series stainless steel. This will result in large inventory build of nickel and subsequent reversal in the market perception regarding the supply and demand dynamics for nickel

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