Nickel, Cobalt & Manganese

History and Factors Affecting Future Demand

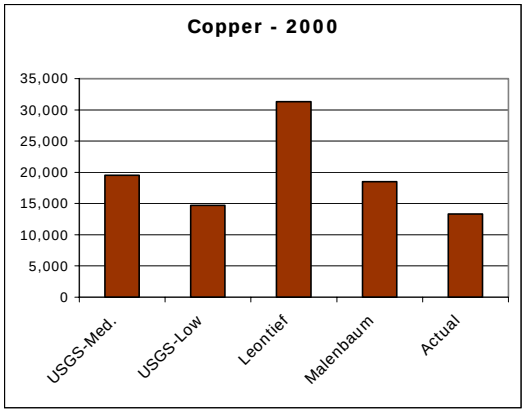
Difficulties of Projecting Demand

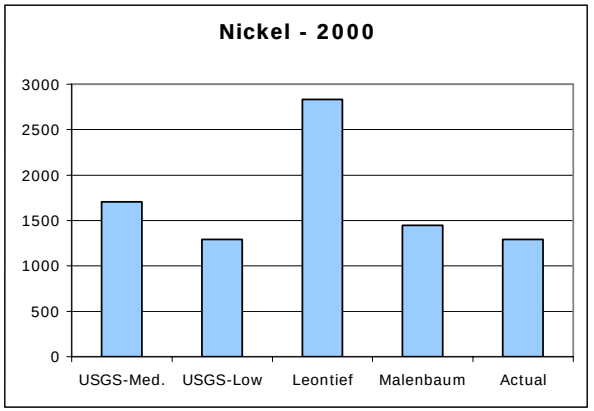
- Metal Demand is subject to unpredictable factors, both transient and transformational
- Four examples from the mid-1970s demonstrate the difficulty: USGS Medium and Low Projections, Wassily Leontief, and Wilfred Malenbaum

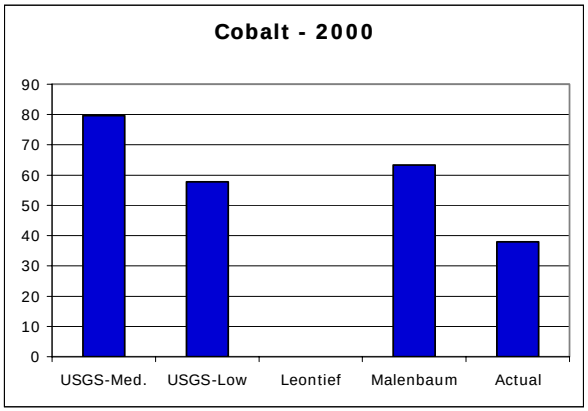
Forecasting Demand is a Risky Effort

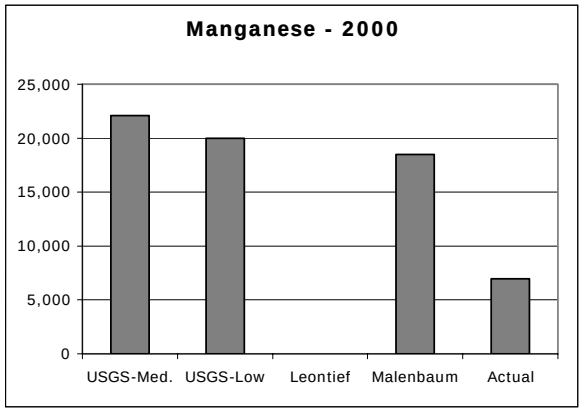
Year	Nickel	Copper	Cobalt	Manganese
USGS-Med.	1705	19,500	79.7	22,100
USGS-Low	1290	14,700	57.8	20,000
Leontief	2833	31,300		
Malenbaum	1446	18,523	63.3	18,503
Actual	1290	13,300	37.9	6,960

Rating the Projections

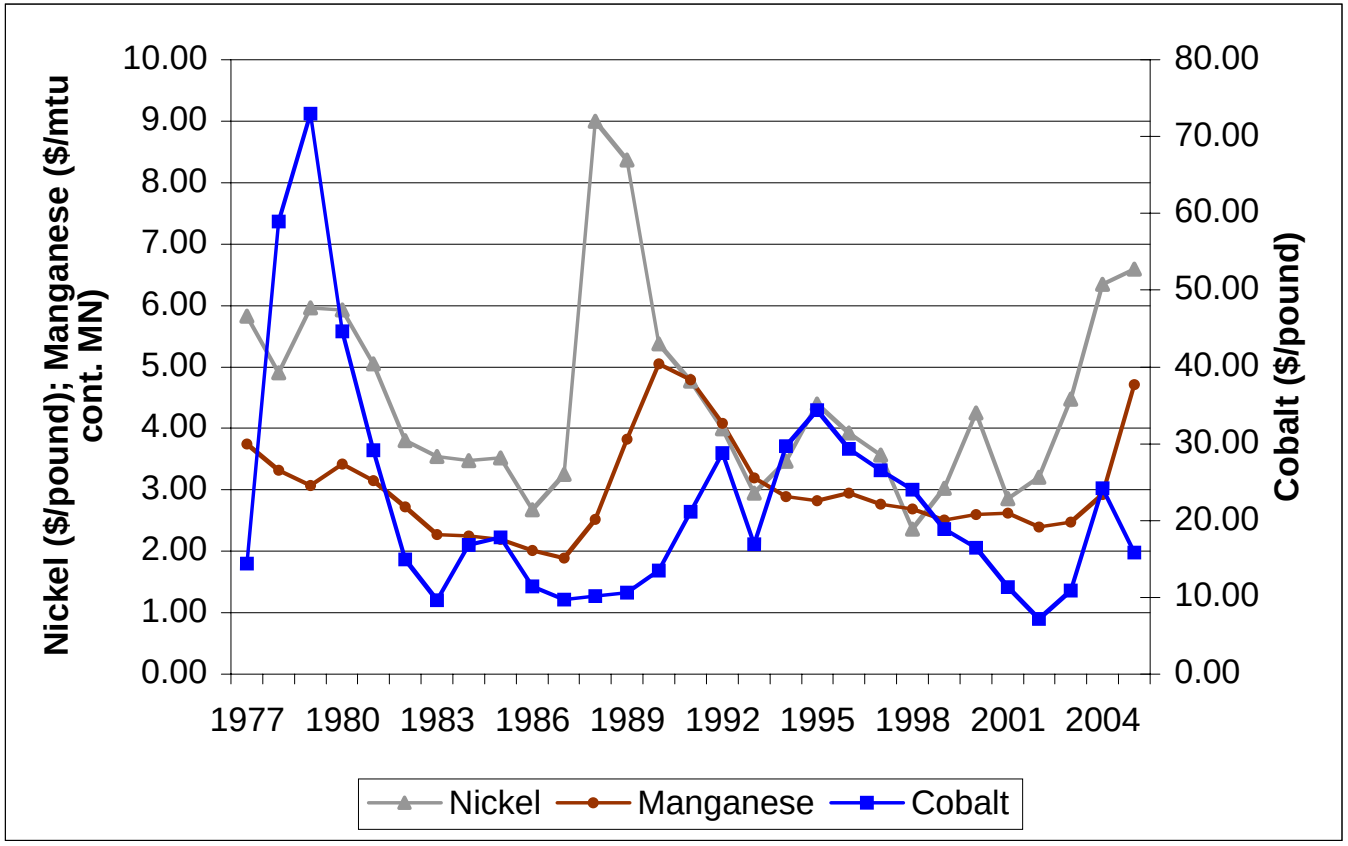




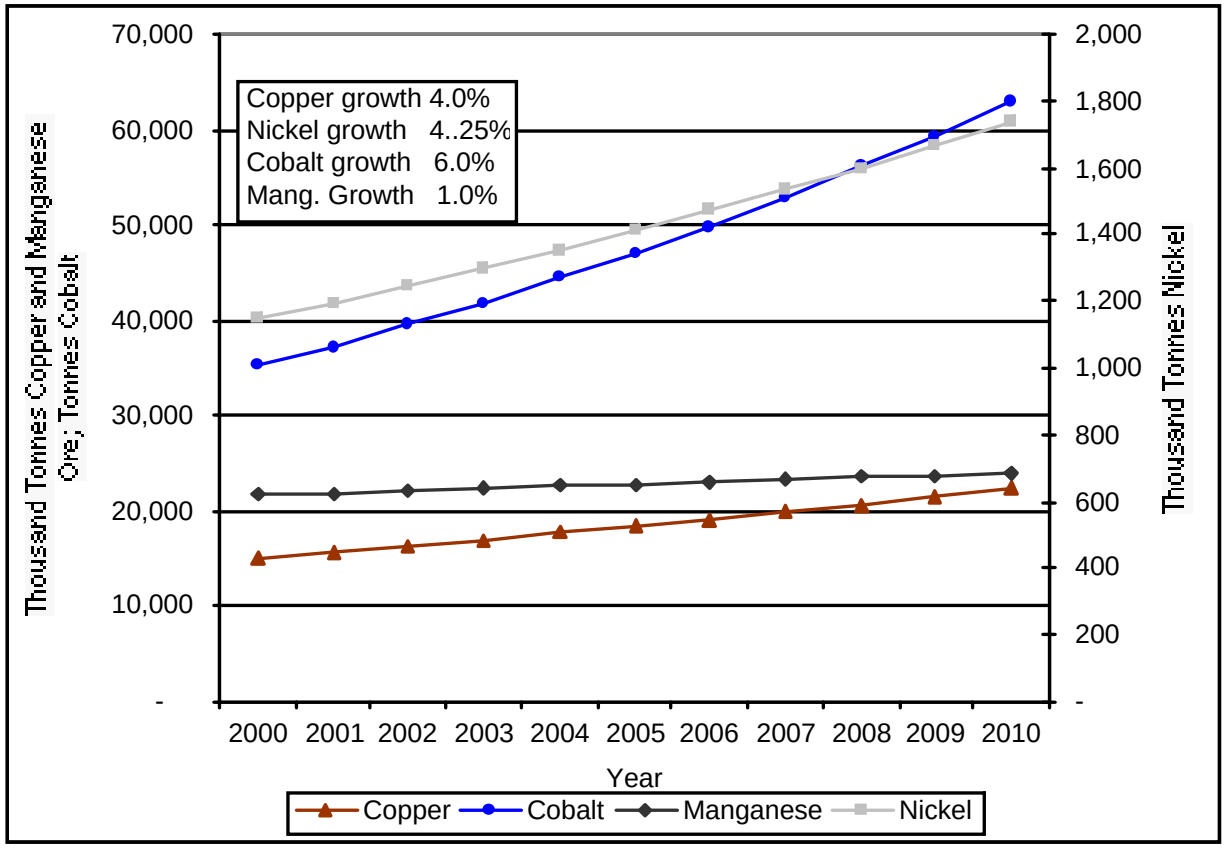




Nickel, Cobalt and Manganese Prices
(2005 Dollars)



Demand Projections based on Recent Trends



Nickel

- Component in most Stainless Steels
- Element in some Steel Alloys
- Plating
- Batteries (Ni-MH) are a small but growing use of Nickel
- 2005 Mine production: 1.5 Million Tonnes
- Reserves: 62 Million Tonnes

Western World Nickel Use in 2000

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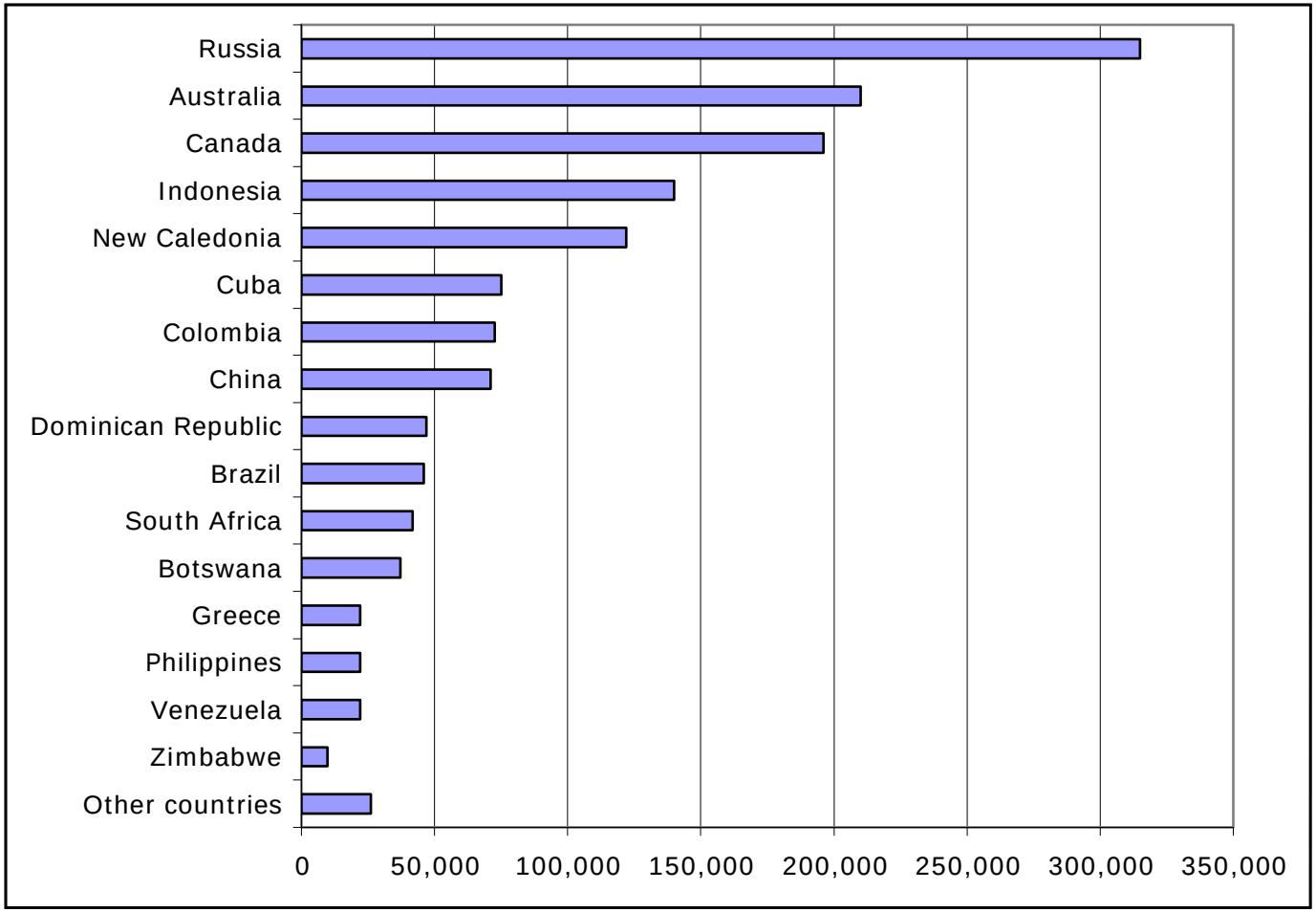
TIFF (LZW) decompressor
are needed to see this picture.

2005 Nickel Production

(Thousands of Tonnes)



Nickel and Stainless Steel Demand Growth

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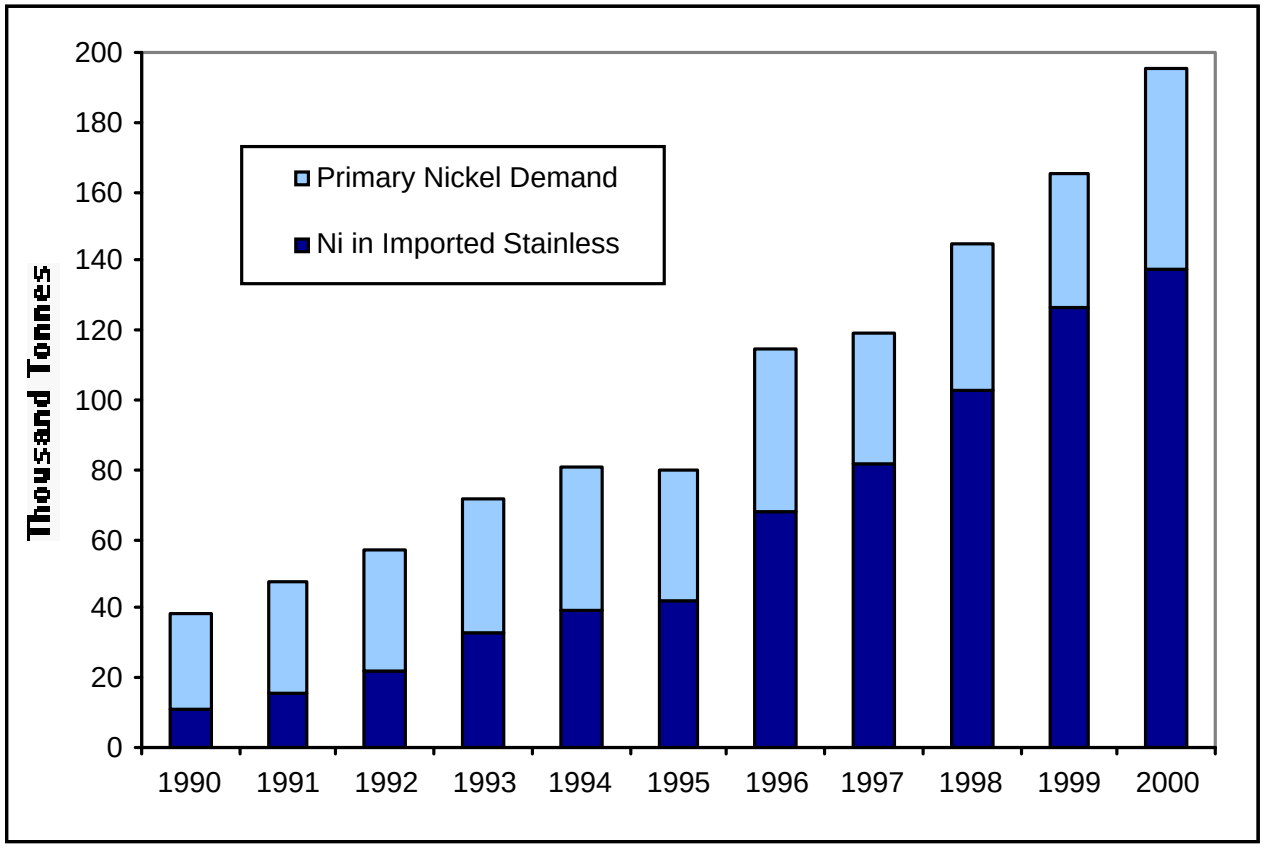
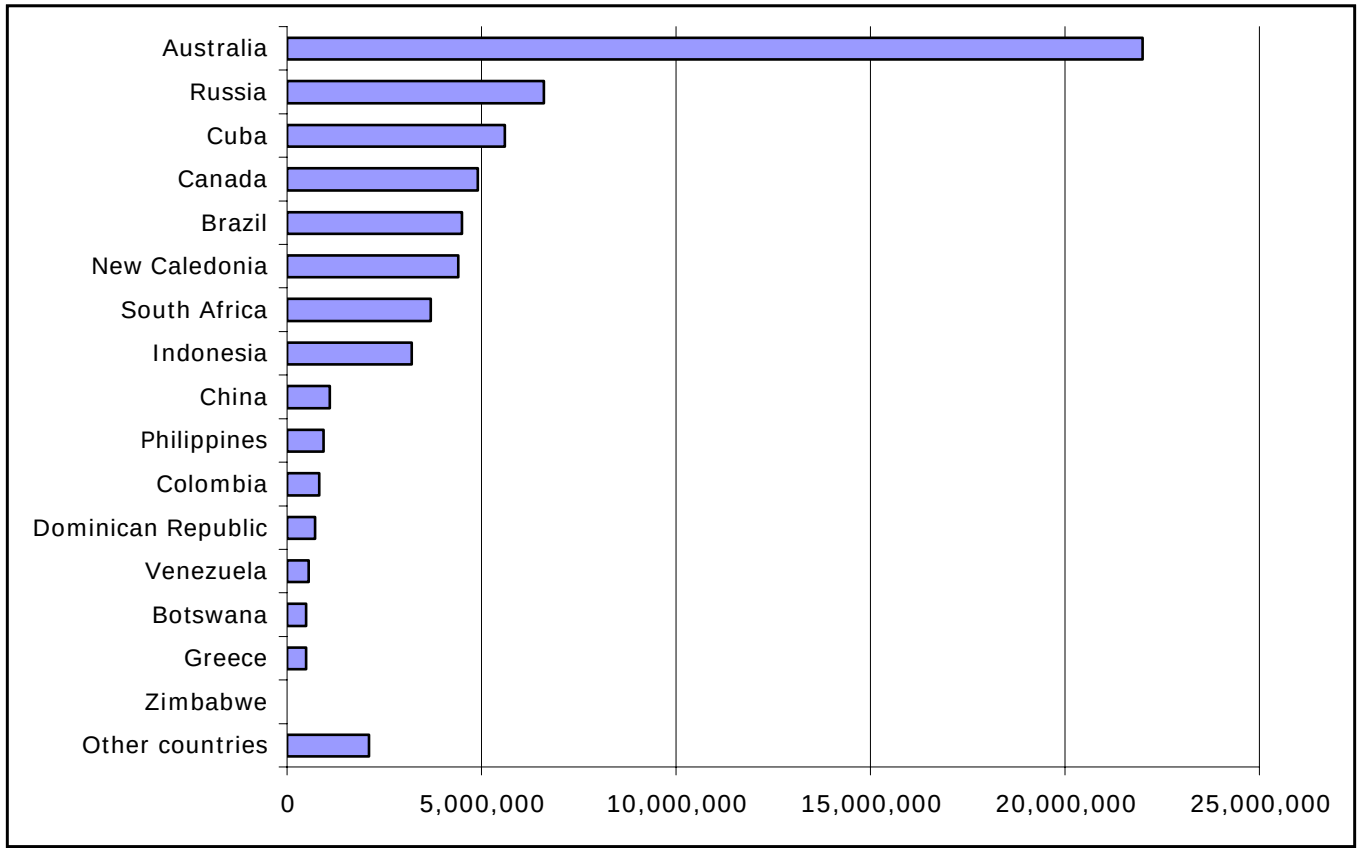
Nickel Demand in China



Nickel Reserves



Cobalt

- Essential Metal for Advanced Economies: Superalloys, Carbides, Batteries, Tool Bits and Surface Treatments
- Nickel Can Substitute for Cobalt in Some Applications, but not all
- Generally Cobalt is a by-product of Nickel or Copper Production
- 2005 Mine Production: 52,400 Tonnes
- Reserves: 7,000,000 Tonnes

Uses of Cobalt

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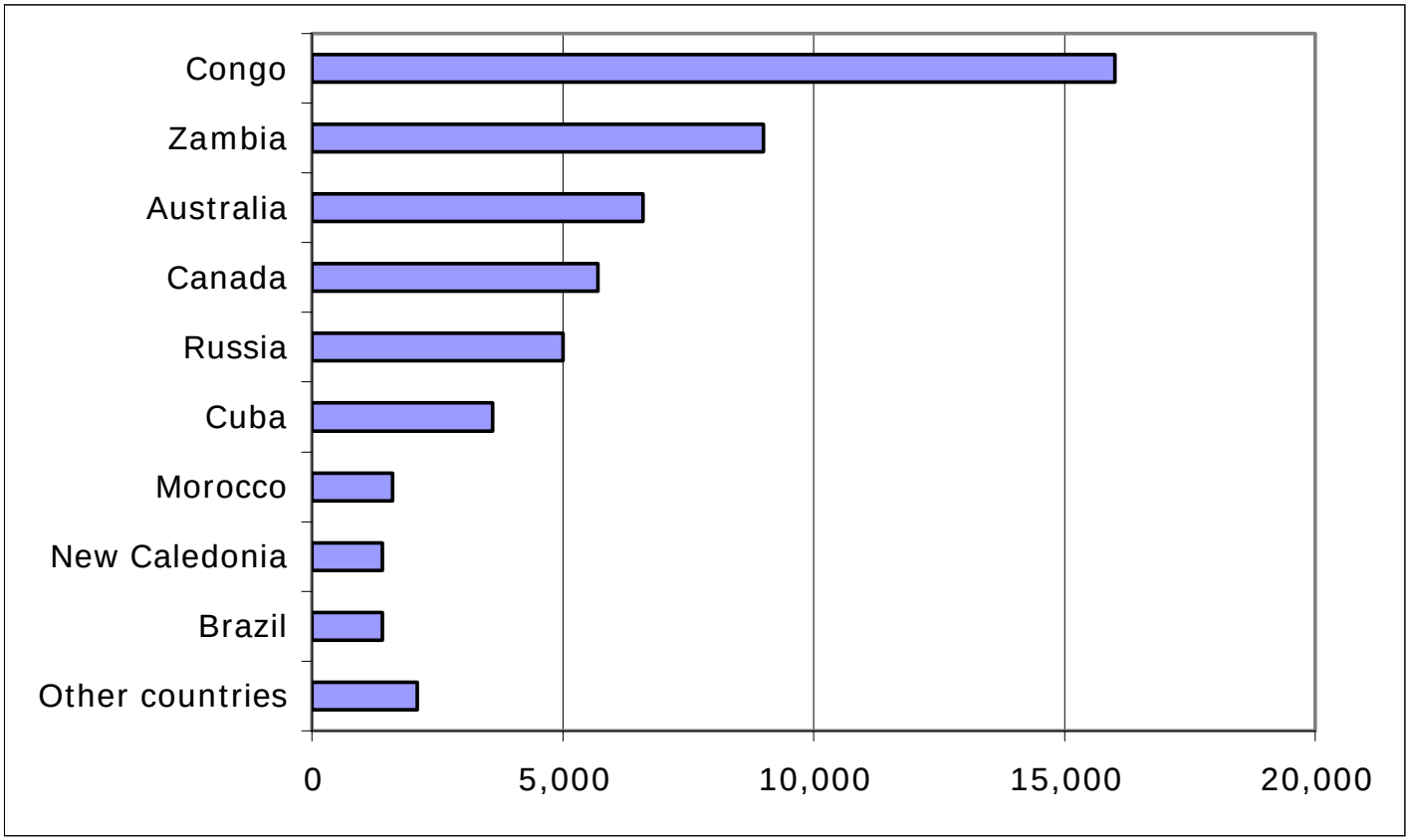
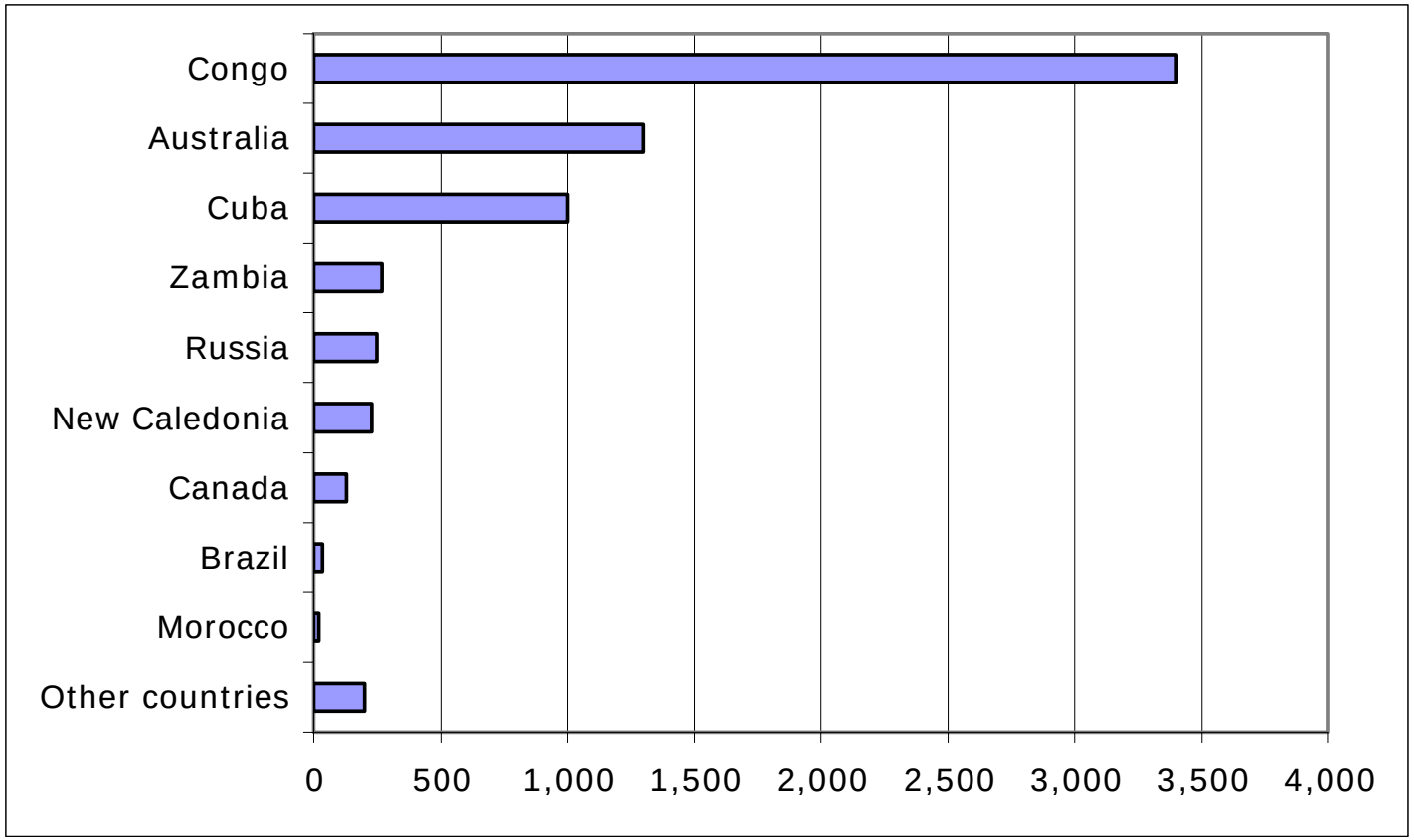
2005 Cobalt Production

(Tonnes)



Cobalt Reserves

(Thousands of Tonnes)

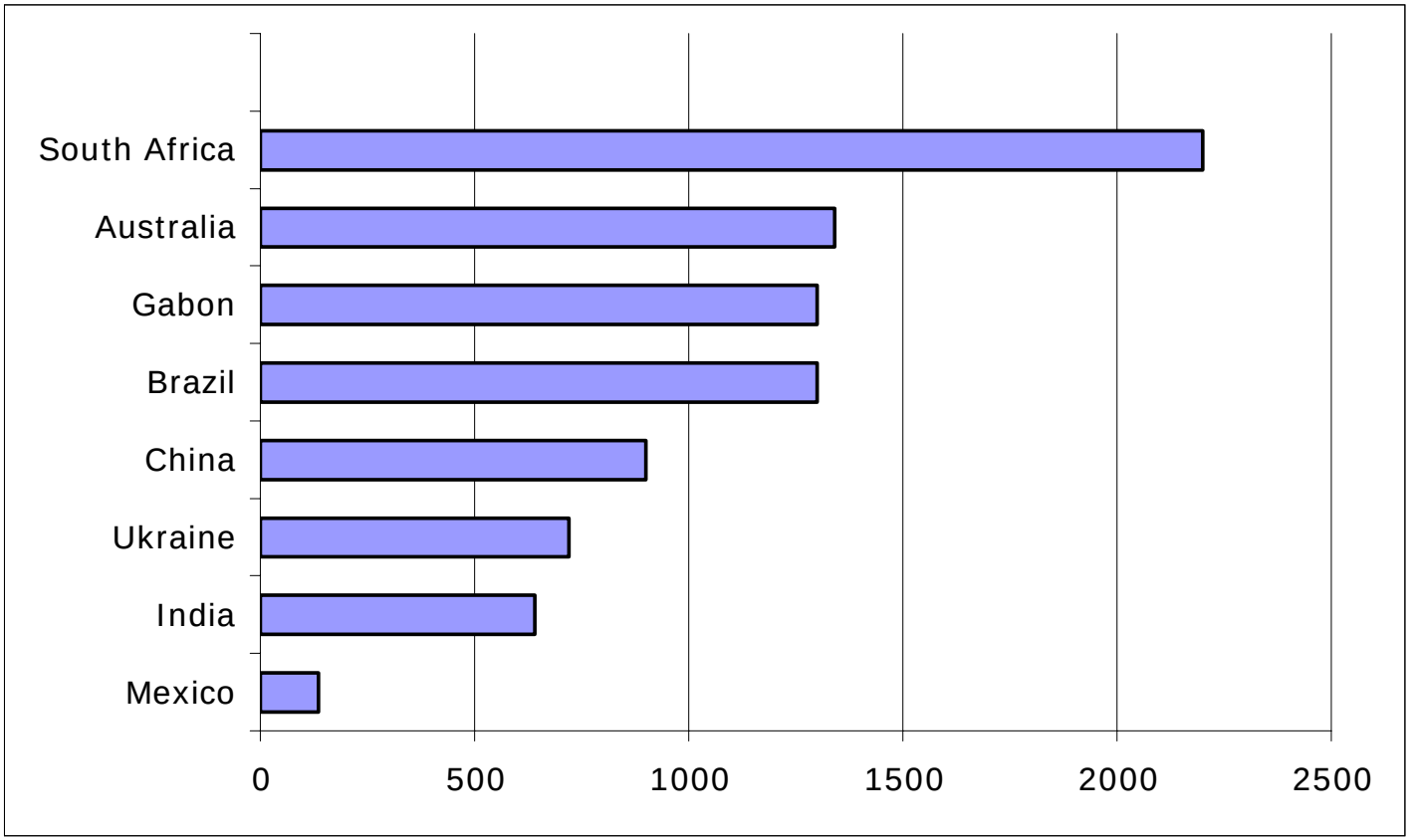


Manganese

- Primary use is in steel production
- Specialty steel and aluminum alloys
- 200 Series Stainless Steel
- Batteries: Conventional Alkaline and Advanced Lithium-Ion
- 2005 Production: 9,790 Thousand Tonnes
- 2005 Reserves: 430,000 Thousand Tonnes

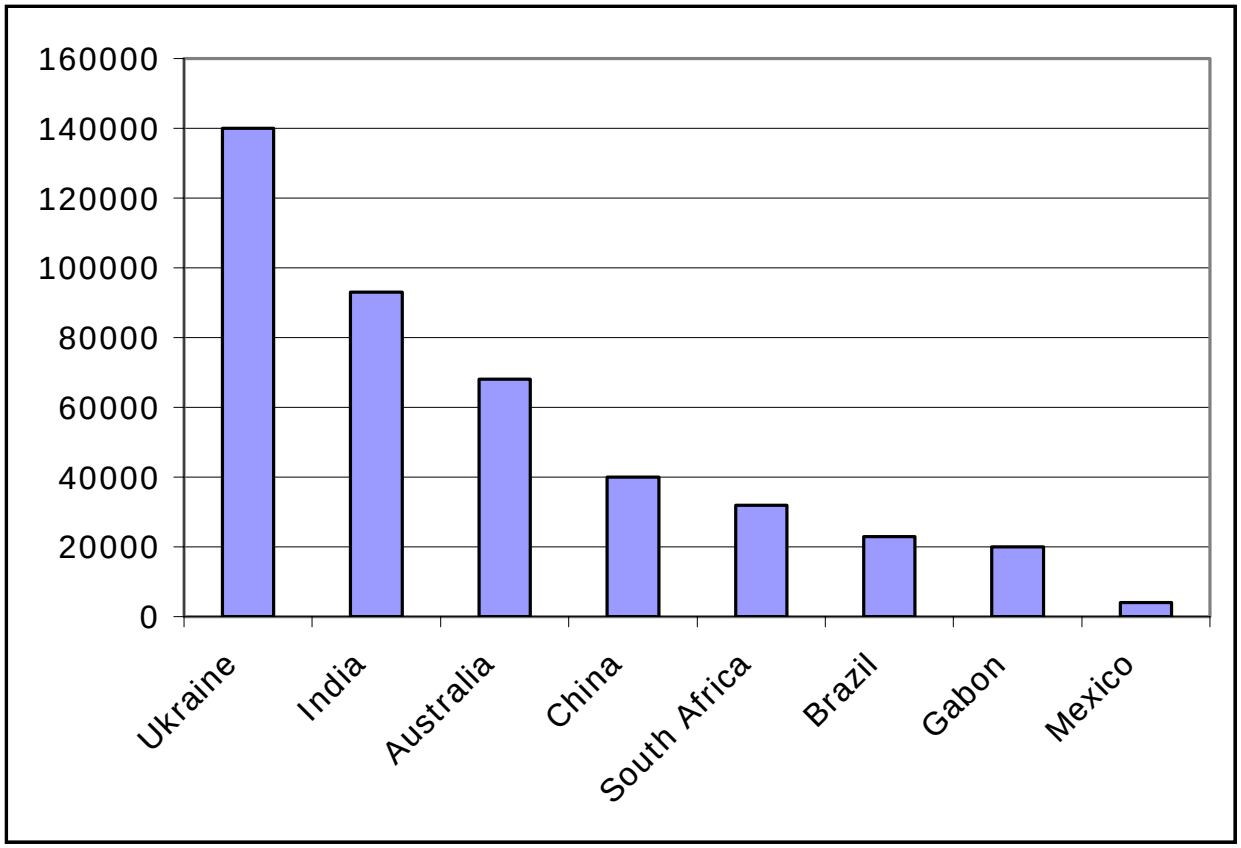
2005 Manganese Production

(Thousands of Tonnes)



Manganese Reserves

(Thousands of Tonnes)



Potential Demand Change: Automobile Design

- Rising Fuel Costs are promoting innovations in automobile design
- Major Competing Technologies are Advanced Diesel Engines and Hybrid and Electric Vehicles.
- Current and projected designs of hybrid and electric vehicles use batteries based on metals from nodules and crusts
- Changes in SLI systems (12 volt vs 36 volt)

US Sales of Hybrid Cars by Month

Nickel and Cobalt in Batteries for Hybrid Vehicles

Metal/ Battery Type	Battery Weight, 3 kwh battery (Kg)	Metal Content 3 kwh battery (Kg)
Nickel/ NiMH	50	12
Cobalt/ Lithium Ion	22.65	4.08
Lead/Lead Acid	85.71	60

Implications of Battery Choice

- Annual World Production exceeds 55 Million Automobiles/year
- 10% Penetration by Hybrid Vehicles could require 66,000 tonnes of Nickel or 16,500 tonnes of Cobalt (4.5% or 31% of current world production respectively)
- Alternative Lithium-Ion batteries could use Nickel, a Nickel/Cobalt combination or Manganese

Battery Design Continues to Evolve: Manganese Li-Ion

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TIFF (LZW) decompressor
are needed to see this picture.

Some Factors Affecting Nickel, Cobalt and Manganese Supply

- Supply
  - Stability of Cobalt exports from the Dem. Rep. Of Congo
  - Russian Export vs Domestic Consumption of Nickel
  - Development and Expansion of Major Nickel Deposits (Vosey's Bay, Goro)
  - Improved application Pressure Acid Leach processing for Laterites

Factors Affecting Nickel, Cobalt and Manganese Demand

- Economic Growth in China and other Developing Countries
- Use of 200 Series Stainless Steel in place of Nickel-based Stainless
- Adoption of Hybrid and Electric Automobiles with High-Capacity Batteries

Implications for Seabed Production

- Land based reserves of Cobalt, Nickel and Manganese can need demand, so metals from the seabed must compete for market
- Economic growth in China and Russia, followed by India and Brazil, will increase need for new sources of nickel and cobalt
- By-product relationships are advantage for seabed minerals
- Long term contracts for production of specialty products (electrolytic manganese, nickel and cobalt for batteries) could reduce risk and improve economic outlook