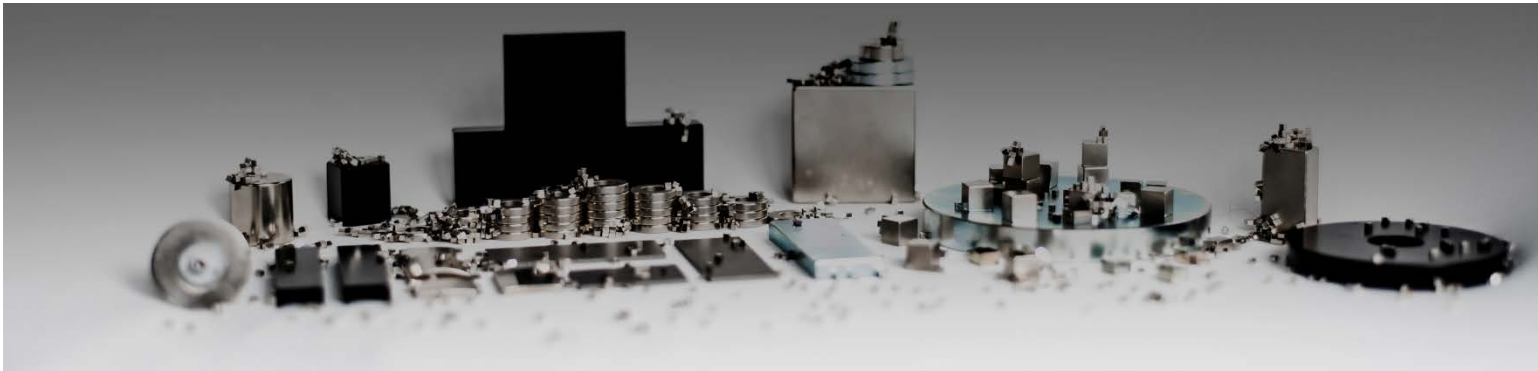
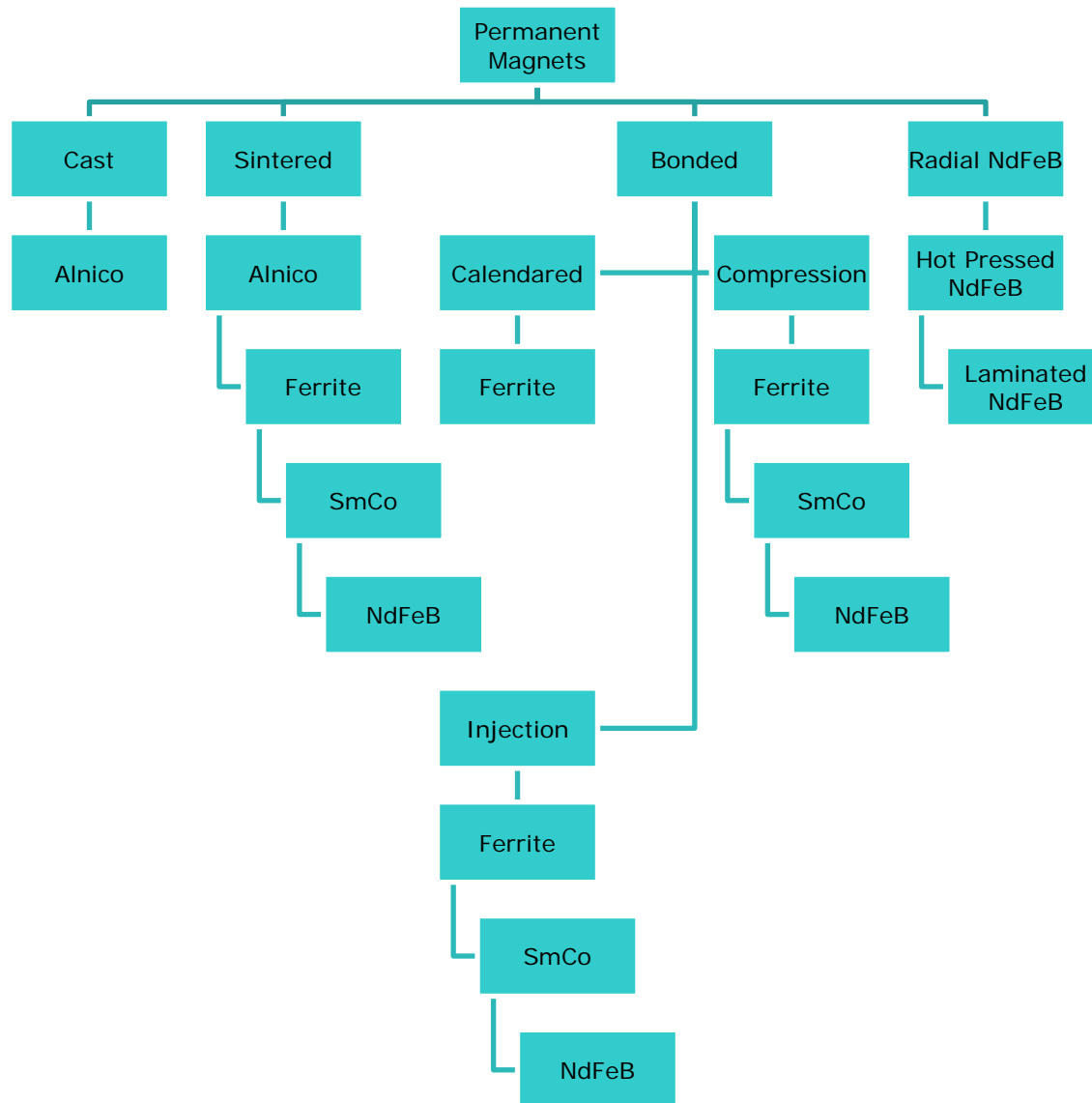


# Permanent Magnet Economics



**Robert Wolf**  
**Alliance LLC**

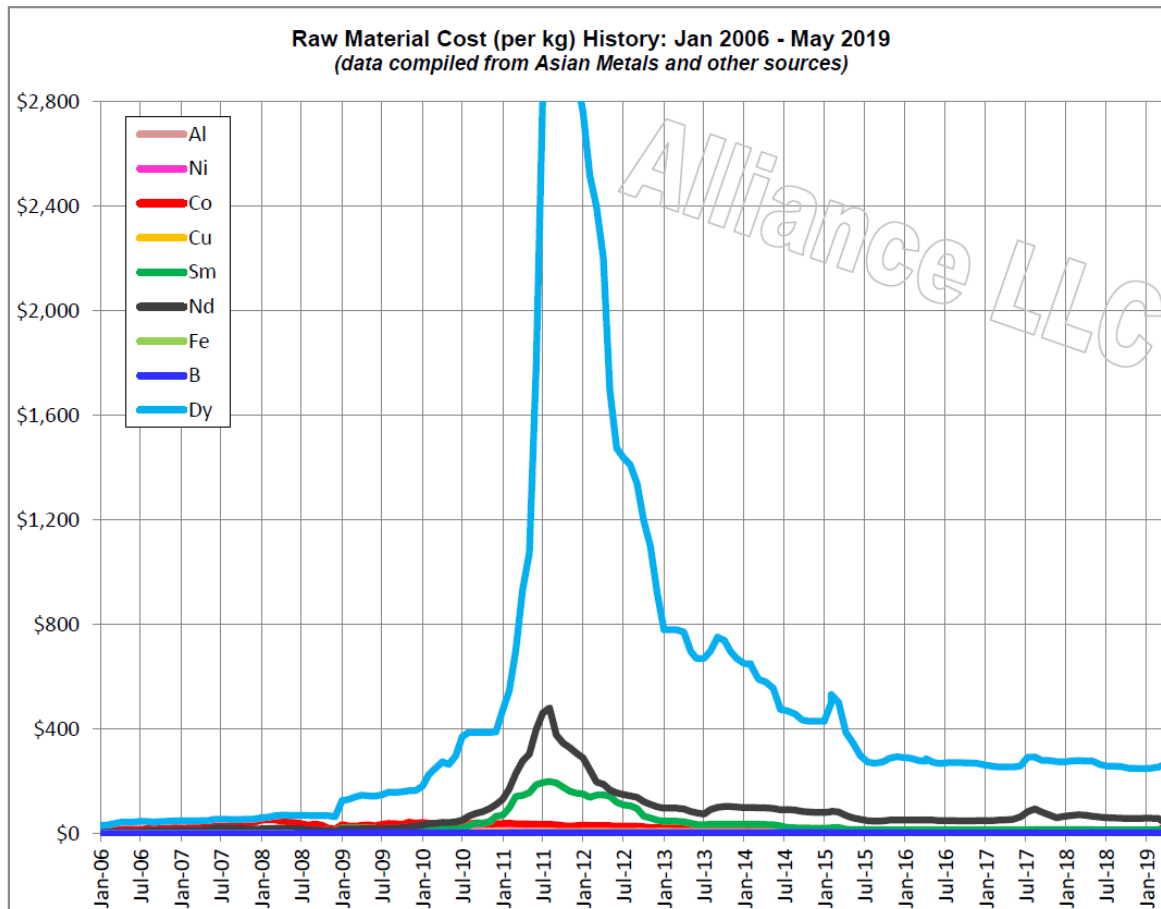
# The Magnet Family



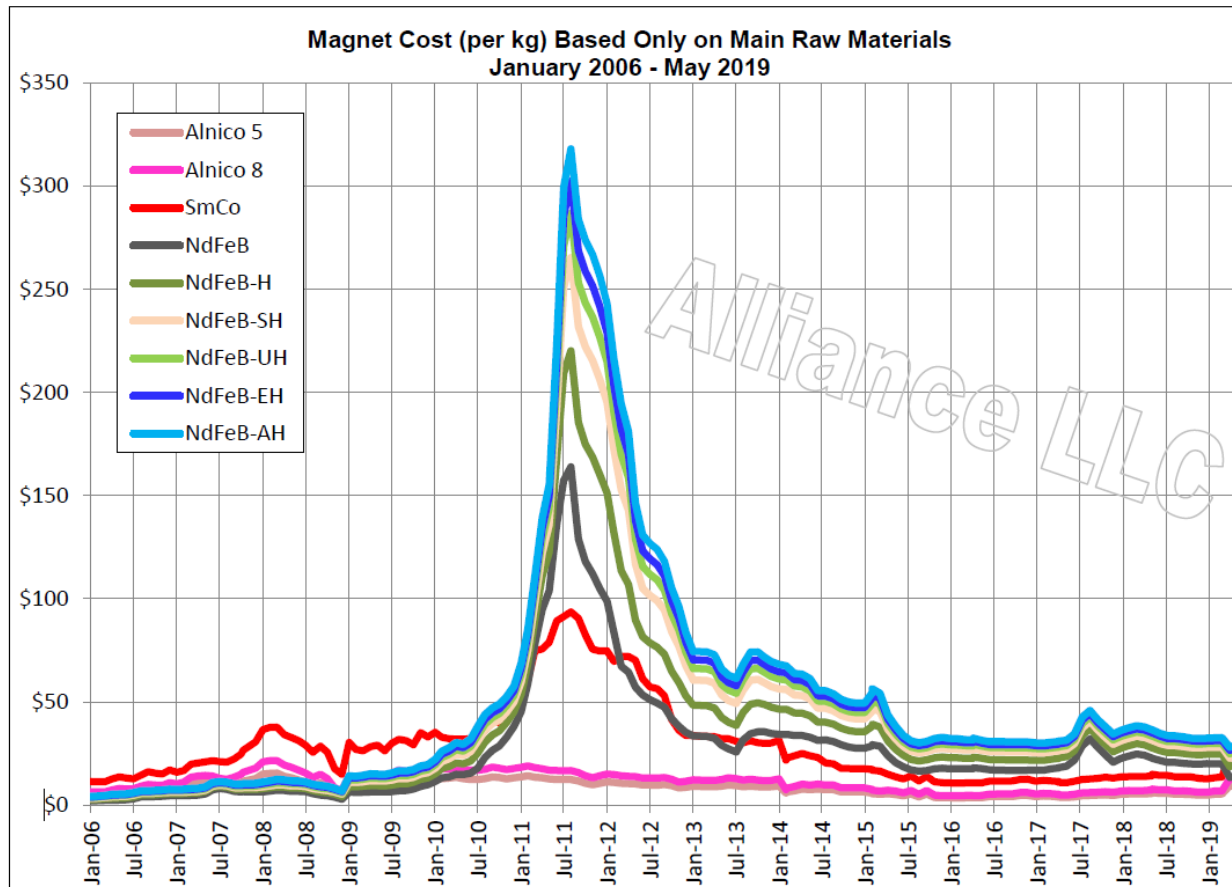
# Magnet Materials

Materials	Typical Shapes	Pros	Cons
<b>Cast Alnico</b> <b>AlNiCo</b>	Rods, Bars, U shape and other cast type	High Br High working T Good T coef.	Very Low Hc High cost High L/D Requires Cast
<b>Sintered Alnico</b> <b>AlNiCo</b>	Powder pressed to shape	Complex shapes High Br, T	Requires Tool High cost Low market
<b>Ceramic/Ferrite</b> <b>SrFe<sub>2</sub>O<sub>3</sub></b>	Blocks, Rings, Arcs, Discs	Most flux for \$ High usage Low corrosion	Low Br Requires tool Simple shapes
<b>Samarium Cobalt</b> <b>SmCo</b>	Blocks, Rings, Discs Arcs, Segments	No corrosion Very low T coef Stable, No tool	Very expensive Simple shapes High Co content
<b>Neodymium</b> <b>NdFeB</b>	Blocks, Rings, Discs Arcs, Segments	Highest magnetic properties No tooling	Corrodes Low working T Difficult to Mag
<b>Bonded Grades</b> <b>All materials</b>	Difficult geometries Can be insert molded or overmolded	Complex shapes Various resins	High toolings Low magnetics High volumes

# Material Costs For Magnets



# Magnet Costs Based on Materials



# Cost Considerations

- Energy
- Materials
- Labor
- Government Regulations
- Environmental Issues
- Taxes—VAT, import, export, income
- Shipping
- Currency exchange rates

# Primary Sources of Energy

- Coal
- Oil
- Wind
- Hydroelectric
- Nuclear
- Solar

# Energy used to Mine & Refine Materials

- Aluminum
- Nickel
- Cobalt
- Rare Earth
- Iron Oxide
- Steel



# Materials Used in Manufacturing

- Magnets
- Batteries – Lithium ion & NiMH
- Catalysts for
  - a) petroleum refining
  - b) automotive catalytic converters
- Paints & pigments
- Super alloys
- Lighting
- Motors & Generators

# Applications of Magnets

- Transportation – cars / trains / airplanes / trucks / ships
- Construction – home / commercial
- Energy Production – generators / batteries / flywheels
- Environment – air purifiers / water purification
- Military – Defense equipment
- Industrial – motors / sensors

# Rare Earths

- In 2019, Rare earths were minimally mined in the United States at Mountain Pass CA.
- Bastnäs site deposits in China and the United States constitute the largest percentage of the world's rare earth economic resources
- cerium compounds used in automotive catalytic converters and in glass additives and glass polishing compounds;
- rare-earth compounds used in automotive catalytic converters and many other applications;
- yttrium compounds used in color televisions and flat-panel displays, electronic thermometers, fiber optics, lasers, and oxygen sensors; and phosphors for color televisions, electronic thermometers, fluorescent lighting, pigments, superconductors, x-ray-intensifying screens, and other applications

# Rare Earths

- mixed rare-earth compounds and for rare-earth metals and their alloys used in armaments, base-metal alloys, lighter flints, permanent magnets, pyrophoric alloys, and superalloys.
- rare-earth chlorides used in the production of fluid cracking catalysts used in oil refining.
- The trend is for a continued increase in the use of rare earths in many applications, especially automotive catalytic converters, permanent magnets, and rechargeable batteries for electric and hybrid vehicles.

# Iron Oxide for Ferrite Magnets

- Byproduct of the pickle liquor from production of cold rolled steel (CR)
- CR steel is used primarily in automotive and white goods markets, both of which are depressed
- Consequently, the production of iron oxide is drastically reduced

# Iron Oxide Usage

- Historically for 10% pigment, 20% water treatment and 70% ferrite
- Now its 10% pigment, 40% water treatment and 50% ferrite BUT
- CR Steel production is off by 50% causing a
- Oxide shortfall of 50%

# World Steel Production 2018 (thousands of metric tons)

EU/Europe/CIS	168,200	9.3%
N America USA	86,700	4.8%
N America Other	33,200	1.8%
Asia China	928,300	51.3%
Asia Japan	104,300	5.8%
Asia other	109,800	6.1%
Other	378,000	20.9%
Total	1,808,600	100.0%

# Iron Oxide Availability

- Water treatment market is increasing
- They used to take ferric oxide and convert to ferric chloride
- Now they buy the ferric chloride directly, in bulk, with no special packaging at the same or higher price as the ferric oxide.
- Consequently, less material and higher prices for magnet production.



# Iron Oxide & RMB History 2007-2013

