

## ► Magneto-Politics, or What's Going On With NEO? By Steve Mowry

Rare Earths (RE) refer to metallic elements of atomic number 57 through 71 on the periodic table (**Fig. 1**), including neodymium (Nd) and samarium (Sm). REs have properties that make them essential for applications including miniaturized electronics, computer disk drives, display screens, missile guidance, pollution control catalysts, and advanced materials; along with very high tech applications like vehicles that don't require drivers, drive motors for electric cars, some lasers, super roller-coasters, robotics, and maglev applications.

### History of Rare-Earth Magnets

The story of neodymium-iron-boron magnets really begins in 1972 when Dr. Karl J. Strnat and Dr. Alden Ray developed a high energy product, 30 MGOe Samarium-Cobalt ( $\text{Sm}_2\text{Co}_{17}$ ) compound. Concerned about the political stability of the majority sources of cobalt in Zaire and Zambia (**Table 1**) and with lucrative Pentagon funding, engineers and scientists at General Motors in 1983 developed a higher energy product, 35 MGOe Neodymium-Iron-Boron ( $\text{Nd}_2\text{Fe}_{14}\text{B}$ ) compound. Remember AlNiCo magnets with a 10 MGOe energy product? Only vaguely! While over in Asia at about the same time, Sumitomo

Special Metals and The Chinese Academy of Sciences independently discovered the new permanent magnet material composed of neodymium, iron, and boron.

In 1986 Magnequench began its corporate life as a subsidiary of General Motors. Magnequench began manufacturing NdFeB magnets in 1987 at its factory in Anderson, Ind. In 1995, the Sextant Group purchased Magnequench from GM, an investment company headed by Archibald Cox, Jr., who is the son of the Watergate prosecutor. After the takeover, Cox was named CEO of Magnequench. He remains at the helm today.

What few knew at that time was that Sextant was largely a front for two Chinese companies, San Huan New Material and the China National Non-Ferrous Metals Import and Export Corporation. Both of these companies have close ties to the Chinese government. Indeed, the ties were so intimate that the heads of both companies were in-laws of the late Chinese premier Deng Xiaopeng!

Magnequench's NdFeB magnets are a crucial component in the guidance system of cruise missiles and the Joint Direct Attack Munition (JDAM) "smart" bomb, which is made by Boeing and had a starring role in the spring 2003 bombing of Baghdad. Magnequench enjoys a near

monopoly on this market niche, supplying 85% of the RE magnets that are used in the servo motors of

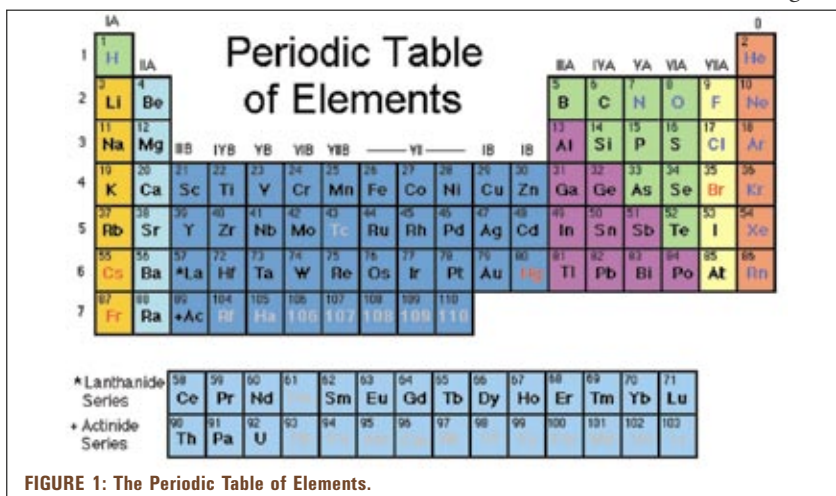


FIGURE 1: The Periodic Table of Elements.

**Table 1** Known World Cobalt Reserves

Country	% of known reserves
Zaire & Zambia	42.4%
Australia	10.1%
Canada	8.0%
Cuba	7.2%
Former Soviet Union	6.9%
China	3.6%
Brazil	2.1%
India	1.3%
Other African Countries	6.1%
Others	9.5%

these guided missiles and bombs to Uncle Sam.

The Committee on Foreign Investment in the United States approved this sale on the condition that the company's manufacturing facility would remain in the US. However, in 2002 Magnaquench closed the Anderson plant and consolidated all magnet powder production at their Tianjin, China facility.

The Mountain Pass rare earth mine in California (**Photo 1**) is the only major RE mine in the US, but it has been closed since 2002 due to environmental and economic factors. The rapid expansion of Chinese output, along with the 2000-2001 Silicon Valley hi-tech crash, led to a collapse in prices that made it difficult for other producers to compete. Analysts say that in 1992 Deng Xiaopeng coined the slogan, "There is oil in the Middle East, there is rare-earth in China," to start the expansion of the country's industry. China has since introduced export quotas for its domestic producers in a bid to control supply and prop up prices.

The Mountain Pass Rare Earth Mine lies between Las Vegas, Nev., and Baker, Calif., and borders on the Mojave National Preserve. It is the only RE mine in the US that produces a group of minerals called lanthanides. The EPA had listed Mountain Pass as California's largest polluter.

### Some Of The Facts

The recent sharp price increases and supply shortfalls are related to the following:

1. The Chinese government has recently begun to enforce certain environmental regulations, which have caused the supply of RE materials to decrease and the cost of production to increase.
2. Southern China had an extended rainy season in 2006, hindering the mining of RE materials and further reducing supply temporarily. Only recently have the mines in southern China returned to normal production.
3. Recently the Ministry of Land and Resources issued new quotas, which have restricted the mining of RE materials and caused the supply to decline.
4. Rare earth elements are all mined at the same time. The mining and separation costs are spread among all the REs. Demand for neodymium magnetic powder is growing rapidly. Demand for other RE materials, such as lanthanum,

**PHOTO 1: View of Mountain Pass Rare Earth Mine from the east slope of Kokoweef Peak (www.schweich.com/images/DSCN0958sm.jpg).**



cerium, and yttrium, show considerably lower growth rates. As such, the cost for supplying all of the RE materials is disproportionately placed upon neodymium.

### Who Has What?

Approximate world RE reserves are listed in **Table 2** by country. Neodymium and samarium are strip-mined together. Large quantities of dirt are required to obtain a small amount of the RE elements.

These figures may be deceptive because it is not currently profitable to mine and process neodymium in the US, Australia, Russia, or Canada. Clearly, China now controls the market. The only major operating RE mine left is located in Baotou, China. China now supplies about 95% of the world's consumption of neodymium, according to mineral industry experts, [www.asian-metal.com](http://www.asian-metal.com).

Cobalt-iron alloys have excellent ferromagnetic properties ([www.s-m-audio.com/whyhiperco.pdf](http://www.s-m-audio.com/whyhiperco.pdf)) in addition to permanent magnet applications.

Table 2 Known World RE Reserves	
Neodymium (Nd)/Samarium (Sm)	
Country	% of known reserves
China	48.0%
Former Soviet Union	21.0%
United States	14.0%
Australia	5.8%
India	1.3%
Canada	1.0%
South Africa	0.4%
Others	7.5%

### How About Russia?

Russia is the world's largest country in land area, occupying 75% of the former Soviet Union. A large percentage of Russian reserves are in remote northern and eastern regions that lack transportation. Although Russia has significant RE reserves and mining was the country's leading industry in 2002, these RE reserves are distant from major population and industrial centers, and experience severe climates. Mining enterprises built there in the Soviet era have curtailed operations sharply but have evidently kept the Polonium (Po, atomic number 84) mines operating. As in other Western countries, the Russian RE reserves will not be tapped until prices rise significantly.

The situation is so serious that Russia announced plans in June 2006 to produce RE metals on the Moon, Deputy Head of the Federal Space Agency Yury Nosenko is quoted by RIA Novosti as saying. Following a May 2006 announcement from the country's largest rocket corporation that it intended to seek helium-3 on the Moon for nuclear fusion, Nosenko said that the agency was aiming to produce the metals for more mundane purposes, and he said, "Rare-earth metals will be used for semi-conductors in modern electronics and medical equipment."

### Patents and Intellectual Property

Of the many US and international patents related to the development and manufacture of RE magnetic products, those related to neodymium-iron-boron magnets are currently valid and enforced by their owners. Of particular importance are those held by Sumitomo Special Metals

Co., Ltd., and Magnequench, Inc. These patents are based on the original intellectual property of General Motors, Sumitomo Special Metals, and The Chinese Academy of Sciences.

Sumitomo and Magnequench have cross-license agreements that cover the sale of NdFeB magnetic products in the US. Only magnets produced under license to these companies are legally entitled for sale in the US. However, most of these are no longer significant; they are dated. Many of the basic Rare-Earth-Iron-Boron patents expired in 2003 and 2006. **Table 3** lists the expiration year for the major patents.

The expired patents provide good references for the technology and information required to manufacture NdFeB magnets. A good patent requires full disclosure.

Table 3 RE Magnet Process Patent Expiration Years				
Company	Patent	Japan	US	Europe
Sumitomo	Basic RE-Fe-B Composition	2003	2003	2003
	RE-Fe, Co-B Composition	2008	2003	2007
	Nd, Dy-Fe, Co-B Composition	2003	2010	2003
	RE-Fe-B Compound	2003	2014	N/A
	RE-Fe, Co-B Compound	2003	2014	N/A
Magnequench	Basic RE-Fe-B Composition	2003	2006	2004
	Including Co	2004	2012	N/A

Source: Sumitomo Special Metals Co., Ltd.

## Future Trends

Certain events could either slow down or stop magnet production in China:

- Strategic military and/or defense issues
- Economic or political collapse in China
- A new breakthrough material

A strong commercial reason such as a trade war or increased tariffs could remove the incentive for purchasing REs overseas, halting or reducing trade by making it too expensive. While always possible, these are unlikely.

Trade could also be reduced or interrupted by military or defense concerns up to and including limited martial law. Magnets are used in some extremely important defense-related equipment. The US could also take steps to stockpile magnets or require that magnets be made domestically again. This would increase short-term demand and certainly drive prices even higher.

While I don't think the political or economic collapse of China is likely, it is a distinct possibility, based mainly on the growth rate of the economy and its size, and on Murphy's Law. There is certainly some chaos associated with business in China today and a small chance that something could trigger a collapse.

A development more specific to the magnet industry would be the discovery of a new material that surpasses NdFeB. This would certainly change the landscape; although, how things would change depends on many unknown factors: the magnetic properties, the cost, the ease or difficulty of manufacture, where the new material is invented, to name but a few.

## My Two Cents

China currently produces approximately 95% of the world's supply of RE ore. This alone gives China an overwhelming advantage in technology both now and in the future. Perhaps this wouldn't be so devastating if China simply exported the stuff for profit like many resource-rich countries. On the contrary, the Chinese unmistakably understand the strategic value of rare earths and have been positioning themselves for years to take full advantage of the situation.

Chinese President Jiang Zemin made the following statement during his 1999 visit to the rare earth rich Baotou region of China within what was formerly known as Mongolia: "Improve the development and applications of rare earth, and change the resource advantage into economic superiority." According to the US-China Economic and Security Review Commission, since the early 1990s Beijing has commenced a "detailed strategy to control the rare earth market." China has done more than just talk—they dropped their prices to cost (driving other world mines out of business), hired between 1000 and 2000 dedicated RE engineers and scientists, built the world's most massive RE devoted research facilities (**Photo 2**), dramatically increased their own consumption, and now they have begun to cut exports.



**PHOTO 2: Baotou City Rare Earth Research Institute (images.nmgnews.com/eng/20051226/23953.jpg).**

Some US officials are aware of the problem, but the US has neither a detailed strategy nor the initiative and resources to contend with this predicament. Currently the US imports 100% of its RE resources (95% from China) and has no stockpile. The US

can't really get tough with China while they control such a vital resource. There just aren't many options available. It's not like we can just reopen Mountain Pass and process the elements into magnets overnight; however, the mine has not been abandoned. The owner, Union Oil Corp, is maintaining the mine or so they claim.

The Chinese strategy may not include generosity. The world is already addicted to rare earth based products, with demand projected to soar from 130,000 tons to 200,000 tons by 2010. To put it in plain terms, we are all junkies and there is only one dealer. China effectively has all the pieces on the board. There is no viable competition at this time.

China can do what it wishes with its own rare earths, leaving the rest of the world to become beggars. China currently has the ability to raise the price of RE, cease export, or use RE strategically by withholding these essential commodities for political, economic, or military reasons. As the significance of rare earths grows with each new technological discovery, China becomes stronger in its strategic position.

The crazy thing is that Deng Xiaopeng warned us almost

15 years ago. Jiang Zemin reiterated the warning seven years ago. Meanwhile, the US has closed its only producing mine, ignored the Rare Earth Information Center, and ceased stockpiling these essential materials.

China put the US on notice that it is playing for keeps, and the Western consuming nations don't seem to care much about the strategic significance of rare earths. However you characterize the RE market situation, NdFeB magnet prices will increase, as demand continues to rise. Unfortunately, it looks as though NdFeB magnets were artificially undervalued when that new woofer was designed. This is not good news for the loudspeaker industry.

The rational remedy? Fund strategic R&D at the great universities and companies in the US and in the rest of the developed world. We must start those high-powered cerebral engines at places like MIT, Stanford, and Cambridge. The rationale for this scenario is that the theoretical (BH)max of NdFeB is about 64 MGOe and the theoretical (BH)max of Fe is 115 MGOe, assuming we could give Fe coercivity without losing too much remanence. It therefore is reasonable to speculate that there may be a material with better magnetic properties than NdFeB. Write to your senators and representatives or to your respective government officials and express concern and ask to support grants and funding for sintered permanent magnet research and development. Let's hope science saves us from this potential disaster. **VC**

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