Technology Intelligence:
Rare Earth Materials and Rare Earth Magnets

Prepared for the Department of Energy

Synthesis Partners, LLC

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Tasking

Synthesis Partners was tasked by the Department of Energy (DOE) Vehicle Technologies Program to undertake research to address the following specific questions regarding rare earth materials and rare earth magnets.

1. Current U.S. mining capabilities, as well as magnet manufacturing capabilities and capacities

2. Plans to expand the mining/manufacturing capabilities in the U.S. in the near-term (over the next 10 years)
    a. Existing industry roadmaps

3. Limitations or constraints on mining/manufacturing in the U.S.

4. Determine requirements for U.S. industries to mine/manufacture these materials and magnets that would include a timeline for production ramp-up if the aforementioned requirements were met

5. Potential for additional (non-Chinese) suppliers to become available and identification of these potential suppliers

Sources and Methods

Synthesis conducted secondary source research on both the rare earth mining and magnetic industry to uncover trends of particular interest to the high-volume, low-cost automotive sector. The research leveraged all data and findings obtained in the Phase 1 work. In this phase, Synthesis pre-screened and reviewed in-depth numerous company sources, technology, business and industry articles, white papers, many web pages, and a number of key conferences. Among the conferences reviewed were the proceedings of the Defense Metals Technology Center's Strategic Metals Conference (April 2009), and the Magnetics Conference 2009 (April 2009). As in the case of the IGBT study, this research did not identify any market research reports that were updates to our Phase 1 research.

In terms of primary source contacts, the following table depicts the companies, industry associations and industry consultants contacted in the course of our research in this phase. In addition, a Synthesis representative attended the panel discussion hosted on Capitol Hill by the Northeast/Midwest Congressional Coalition, entitled, "U.S. Manufacturing in the Strategic Materials Market: An Opportunity for Future Growth" on July 22, 2009. Representatives from the high-performance magnet and rare earth mining industry were in attendance.

Table 1: Primary Contacts

Source	Contact
Companies	
Adams Magnetic Products	Jack Powell
Arafura	Alistair Stephens
Avalon Ventures	Ian London
Electrodyne	Kevin Cook
Electron Energy Corp.	Peter Dent
Hitachi Metals	Brian Brilinski
J.A. Green & Co.	Jeff Green
Jack Lifton, LLC	Jack Lifton
Less Common Metals	David Kennedy
Lynas Corporation	Dr. Matthew James

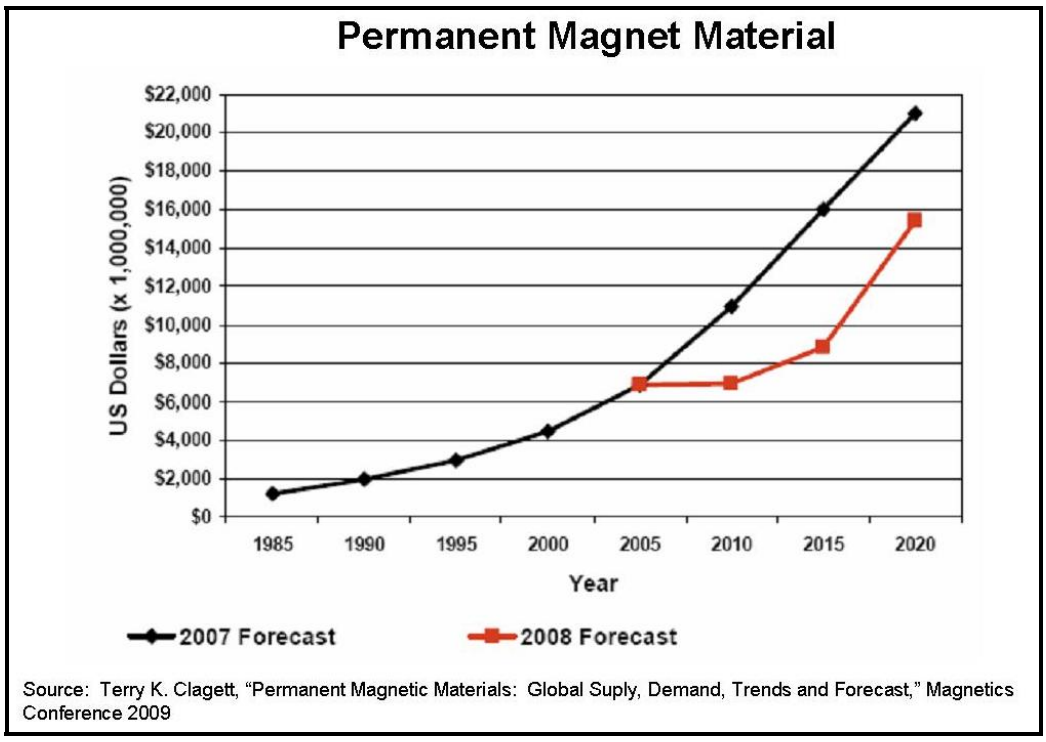
Magnet Applications	Dr. James Bell
Molycorp	Mark Smith
Thomas & Skinner	Ed Richardson
UQM Technologies	Jon Lutz
Walt Benecki LLC	Walt Benecki
Wings Enterprises, Inc	Jim Kennedy
Associations	
U.K. Magnetics Society	J. Ward
Rare Earth Industry and Technology Association	Keith Delaney
Rare Earth Magnetics Association	

1. Current U.S. Mining Capabilities, Magnet Manufacturing Capabilities and Capacities

Update from Global Industry Forecasts and Studies

The industry forecast for the production of permanent magnet material has been revised through 2020. The chart below from Terry Clagett of WebMagnetics.com shows the forecast has been adjusted downward since the original projection developed 12 months ago. The red line indicates the revised growth line.

Figure 1: Global Permanent Magnet Material Production

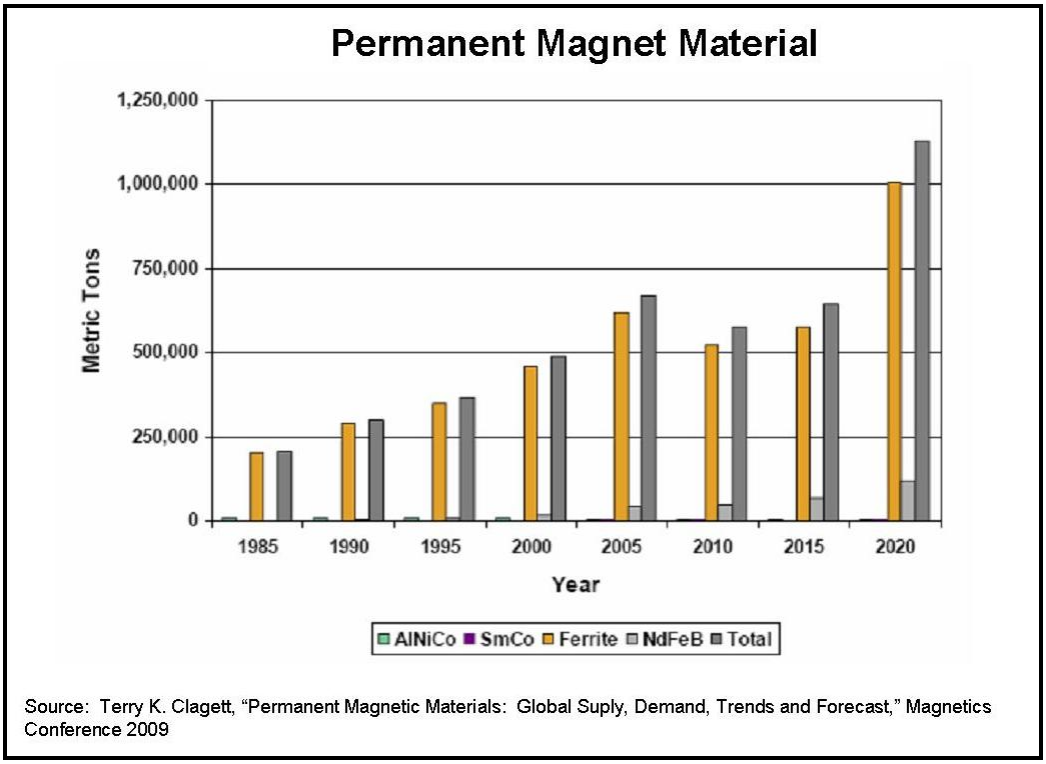


Source: Terry K. Clagett, "Permanent Magnetic Materials: Global Suply, Demand, Trends and Forecast," Magnetics Conference 2009

Growth after 2009 is expected to be slow but steady, with sales in 2020 projected $5.5b lower than previously forecast. Mr. Clagett predicts the global recession will cause the magnetic industry to forego $7.2B in sales by 2015. He estimates the recession will cause a loss to the global economy of 210,000mT of permanent magnet materials and that permanent magnet materials sales will not reach pre-recession levels until 2015-16.

The most widely used magnetic material is ferrite. Ferrite magnet production far exceeds NdFeB production. Mr. Clagett predicts this trend will continue into the future.

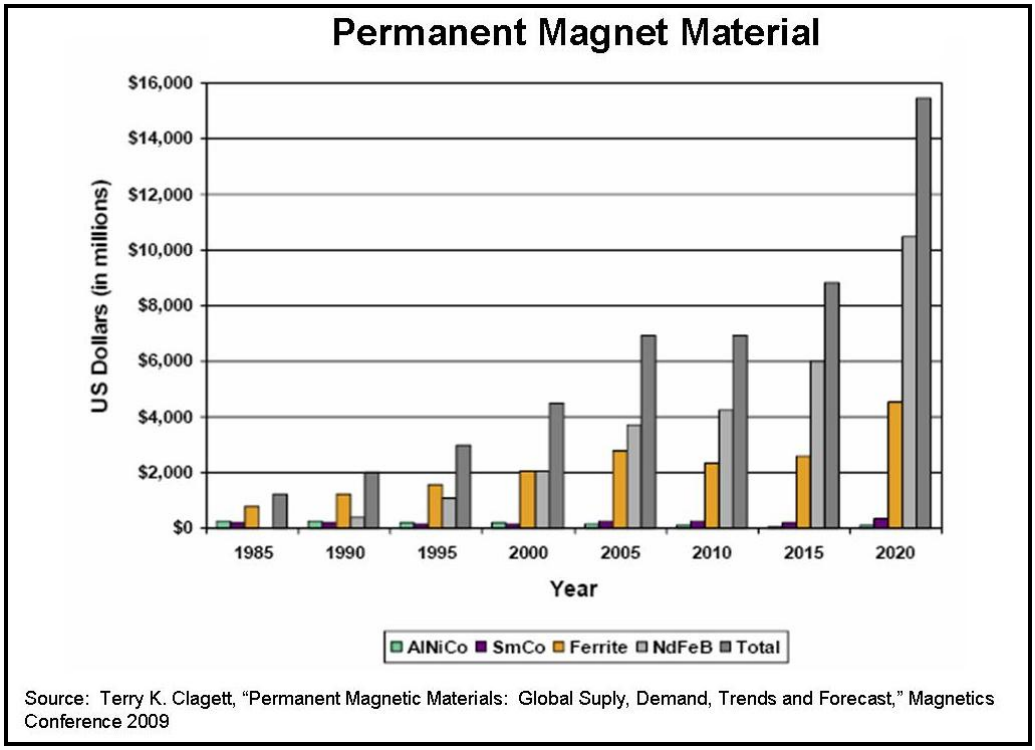
Figure 2: Permanent Magnet Material Production by Type



Source: Terry K. Clagett, "Permanent Magnetic Materials: Global Suply, Demand, Trends and Forecast," Magnetics Conference 2009

Even though the total production of ferrite magnets will outstrip that of NdFeB by weight, the global average price per kilogram of NdFeB is almost 20 times the price of ferrite. The NdFeB magnet market is projected to be over $10B by 2020.

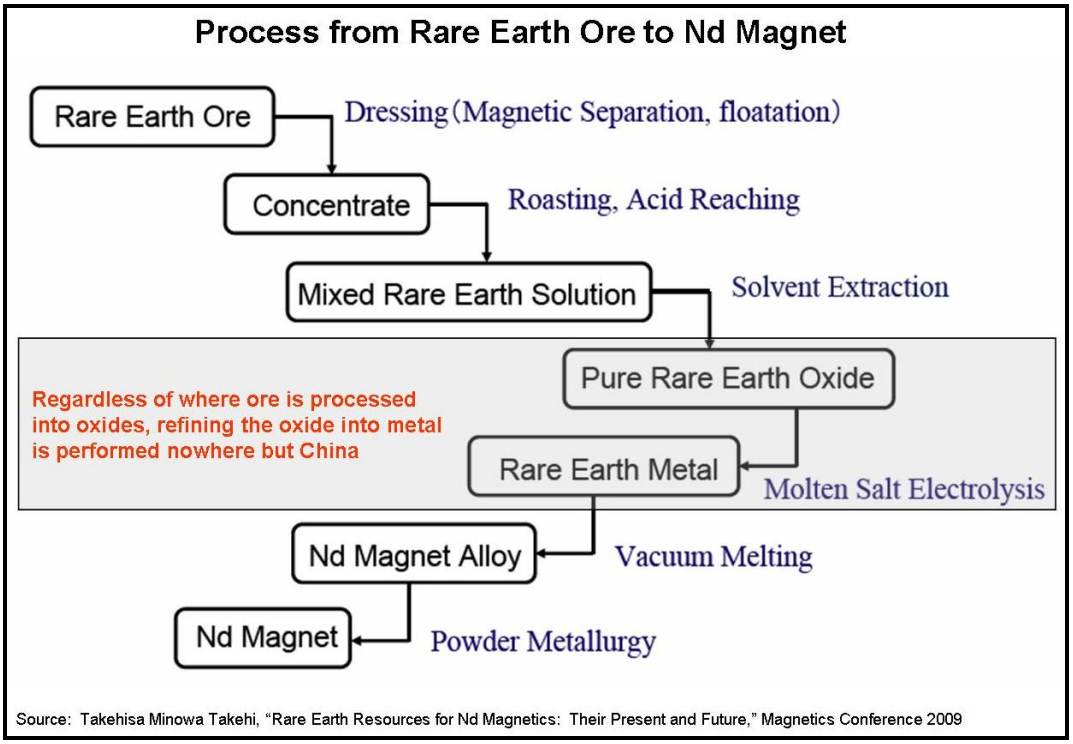
Figure 3: Permanent Magnet Material Sales by Type



Source: Terry K. Clagett, "Permanent Magnetic Materials: Global Suply, Demand, Trends and Forecast," Magnetics Conference 2009

Following up from our Phase 1 study, Peter Dent from Electron Energy Corporation reiterated his concern over the Chinese control of the rare earth industry. Rare earth prices have dropped a bit in recent years, but Mr. Dent is still uneasy due to "a huge lack of transparency" in the Chinese market and their pricing structures.

Figure 4: Rare Earth Magnet Production Process

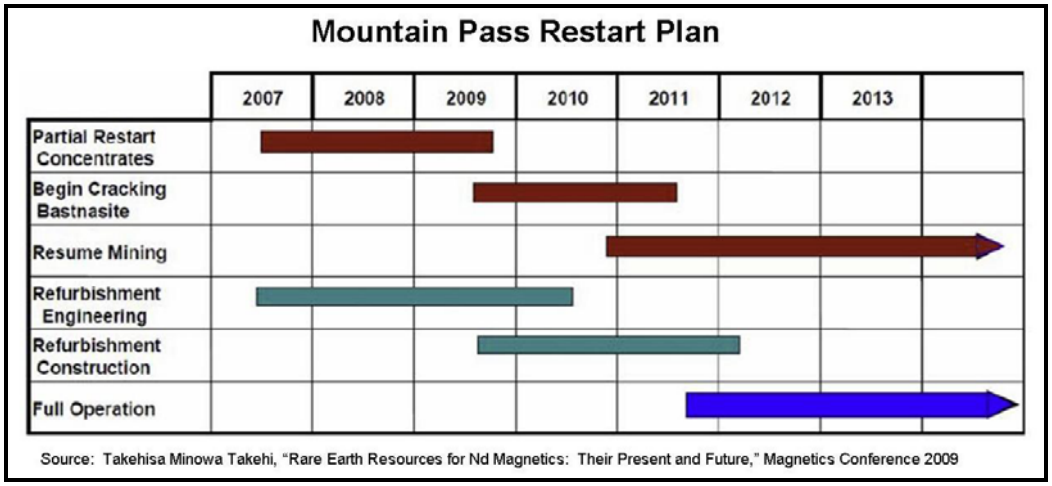


Interestingly, in spite of the apprehensions of many in the U.S. magnet industry concerning Chinese domination, not all customers share their view. Jon Lutz, Vice President for Technology at UQM, a company that manufactures electric motors for the automotive and aerospace industry, indicated that they have no problem with the supply of rare earth magnets they use for their motors, nor does he anticipate any supply problems in the foreseeable future. He states they have "five active suppliers, which are located in China, Japan, and the US." While he did not specify who the suppliers are, the US supplier most likely resells magnets which are made in China, the largest exporter of rare earth magnets.

Current U.S. Mining and Manufacturing Capabilities

The only active rare earth processing facility in the US is Molycorp's Mountain Pass operation in California, which contains one of the world's largest rare earth deposits. It has not yet produced any rare earth metals, though the company is very active in its preparations to do so. Numerous sources, including Peter Dent, report the effort to restart production is still "going strong." They project full operation by midyear 2011.

Figure 5: Mountain Pass Restart Plan Timeline



Terry Clagett states the mine has the potential to produce 4-12,000 metric tons (mT) of rare earth oxides by 2012, while Takehisa Minowa estimates they'll be producing 10,000 mT by 2010.

Table 2: Rare Earth Deposits in the World and Production Scales

	REO (k Mt)	
	Deposit	**Production**
Bayan Obo (China)	3500	75
South China (China)	1000 (?)	35
Sichuan (China)	---	21
Mountain Pass (USA)	4300	10 (in 2011)
Mt Weld (Australia)	1200	10 (in 2009)
Nolans (Australia)	600	5 (in 2011)
Tore Lake (Canada)	200	5 (in 2012)
Total	10200	161

Source: Takehisa Minowa, "Rare Earth Resources for Nd Magnets: Their Present and Future"

Currently there is one company that makes commercial-grade, high-volume rare earth magnets and materials in the U.S. – Electron Energy Corporation, which produces only SmCo magnets. It appears that NdFeB magnetic materials are made overseas, primarily in China, and from predominately Chinese raw materials. With regard to potential suppliers to automotive customers, it appears that the few American companies that sell NdFeB magnets import the magnetic material as billets and magnetic alloy powder from which magnets are manufactured, or they simple import finished magnets.

Molycorp Joint Venture

In mid-July 2009, Molycorp and Arnold Magnetics announced a joint venture to manufacture rare earth magnets in the US. It is noteworthy that Arnold currently does not manufacture rare earth magnets in the US. No public details of the joint venture or timetables for production have been released at the time of this report.

Prior to the Arnold Magnetics JV, Molycorp had expressed interest in purchasing controlling interest in the Great Western Minerals Group (GWMG). Industry analyst Jack Lifton surmises Molycorp's interest was spurred by the production facilities GMWG had previously purchased from Ovonic Materials in Troy, Michigan in 2007 and from Less Common Metals, Ltd. of Birkenhead, UK in 2008. Molycorp withdrew their offer in June 2009 after the negotiations fell through. In the press release detailing the

withdrawal, Molycorp CEO Mark Smith stated "This development in no way changes or delays Molycorp's Mine to Magnets business strategy. While a transaction with Great Western would have been expedient, we already had plans in place to add manufacturing capabilities for rare earth alloys and powders before we were approached by Great Western. We will simply move forward with those original plans on our original time table."

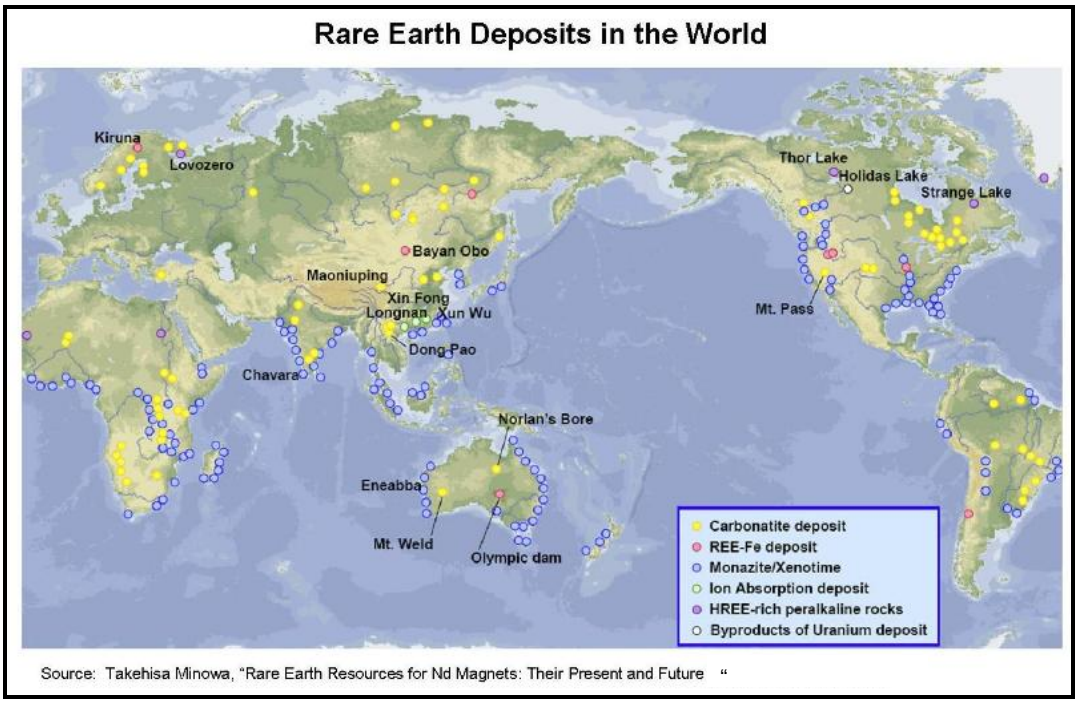
2. Plans to Expand Mining/Manufacturing in the US in the Near-Term

As the map below shows, there are deposits of the many rare earth elements in the US.

- Monazite (cerium, gadolinium, lanthanum, neodymium, praseodymium, samarium, terbium, thulium, yttrium) and
- Xenotime (cerium, dysprosium, erbium, gadolinium, holmium, lanthanum, lutetium, neodymium, samarium, terbium, thulium, ytterbium, yttrium)

However, at the present time the Mountain Pass operation is the only active mining operation (processing tailings) within the country.

Figure 6: Rare Earth Deposits in the World



Small Mining Companies

There are a number of smaller North American mining companies directly or indirectly involved in rare earth exploration and mining. These companies appear to fall into two categories – those which produce rare earth ores and oxides as a byproduct of mining other metals (particularly gold or uranium), and companies which are strictly into exploration and look to other companies to invest in and develop the fields they discover. None of these companies individually appear to be poised to become major rare earth producers. Taken collectively, though, the output of these mines could provide a significant amount of rare earth ores and oxides.

The fate of these smaller mining companies will be affected by the recent two-year "timeout" requested by the Department of Interior with regard to new mining claims on nearly 1 million acres near the Grand

Canyon National Park in northern Arizona. While the timeout focuses on uranium mining in the Grand Canyon area, rare earth by-products in the uranium mines will also be affected.

Synthesis analyzed a selection of these small companies according to their potential impact on the rare earth industry. Below is a summary of their current status and plans. More detailed information on each of these companies can be found in Appendix A.

Table 3: Small Mining and Exploration Companies

Name	Partnerships	Selected Industry Actions and Plans	Location
Eagle Plains Resources Ltd.	None noted	Explores for precious and rare metals, to include rare earths; discovered rare earth ores in the Ice River Complex in British Columbia and will begin exploration this summer.	Canada
Primet LLC	Sichuan Provincial Mining Co, China Baotou Metals, China	Produces and distributes rare earth materials from China	US
Quest Uranium Corporation	None noted	Primarily explores for uranium but branching out into rare earths. Exploring Strange Lake area in Quebec; latest discovery estimated to be 4.35% rare earth oxides. No estimates on total production.	Canada
Rare Earth One LLC	Subsidiary of Ucore Uranium	Developing Bokan Mountain in Alaskan panhandle. Area estimated by USGS to hold 11+ million pounds of uranium as well as tantalum, niobium, and rare earth elements	US subsidiary of Canadian company
Rare Element Resources Ltd.	None noted	Conducting rare earth exploration in Bear Lodge, Wyoming, estimated to be "one of the largest deposits of disseminated rare-earth elements in North America". No estimates on production volume.	Canada
Tombstone Exploration Group	None noted	"Through expansion, the company will acquire new properties, as well as integrate the extraction of precious metals, rare earth and other minerals."	US
Wings Enterprises	None noted; however, company has stated "our best prospects are to sell the project to the Chinese"	Reopening iron ore mine in Pea Ridge, Missouri that contains reserves of rare earth ore estimated at 600,000 mt; REs will be mined as secondary resource to iron ore production which should lower the cost of the iron ore. The reserves here are estimated to be about 14% of those in Mountain Pass.	US
Xploracorp	None noted	Invests in existing mine development, including rare earth mines.	US

Source: Synthesis Partners (2009)

These producers face a number of challenges, not the least being funding to start operations.

Jim Kennedy, President of Wings Enterprises states they "could be producing rare earths within 12 to 14 months" from "75,000 tons of easily accessible rare earths in our tailings lake." Yet, his operation is stalled due to funding. He estimates it would take a bridge loan of $25 million to "put us back on track" and states "currently our best prospects are to sell the project to the Chinese." He also made the point that "even if Wings and Mountain Pass [fully] reopen, there are no domestic refining capabilities in North America. Both companies would be forced to sell our rare earth oxides to Japan or China.

<u>Existing Industry Roadmaps</u>

Research did not uncover industry roadmaps available concerning either the rare earth or magnetics industries in North America. Peter Dent echoed other sources when he stated that he was not aware of any roadmaps, nor was he able to locate any.

3. Limitations or Constraints on Mining/Manufacturing in the US

Rare earth mining started at Mountain Pass in the 1950s. By the 1980s, it supplied most of the world's rare earth minerals. However, in the early 1990s, cheaper Chinese rare earths began eroding the mine's market share as the Chinese initiated a sustained, strategic effort to cut prices. That price competition, combined with increasingly stringent and expensive environmental regulations led to shutting down the Molycorp mine completely in 1998.

Molycorp's resumption of mining operations at Mountain Pass has required coordination and negotiations with 18 different regulatory agencies in California and, according to some reports, will require the company to spend $2.4M annually for environmental monitoring and compliance. These environmental costs plus the start-up and operations costs indicate it will not be cost-competitive with Chinese manufacturers. However, Molycorp CEO Mark Smith is confident that the company will still be successful, stating that the mine's previous customers in the US and Japan "have given their assurances" they'll support the operation. Synthesis assesses that Molycorp and other non-Chinese operations will require the development and/or adoption of game-changer technologies in order to compete effectively with Chinese suppliers.

Currently there is no capability to manufacture NdFeB magnetic materials in the US. Electron Energy Corporation is the only company that produces rare earth magnetic materials in the US and it manufactures only samarium cobalt magnets. When asked about the possibility of producing NdFeB magnetic materials, Electron Energy's Mr. Dent indicated that they were not interested. He explained that although the process and equipment used would be essentially the same for both types of magnets, "cross-contamination" would require replicating the production facilities to accommodate NdFeB production. To be competitive with Japanese or Chinese producers, they would be required to drastically increase their scale of operations well beyond their current capacity to produce SmCo magnetic materials.

The complexity of the manufacturing process, as well as the fact that Arnold Magnetics imports rather than produces NdFeB magnets, leads Synthesis to assess that the Molycorp-Arnold Magnetics JV will take several years to reach an initial operating capability if the goal is to manufacture the magnets in the US. As in the case of Molycorp's mining operations, break-through technology is likely needed to enable sustainable US mining and magnet-producing operations that are able to compete in the world market with dominant Chinese and Japanese firms.

A further limitation or constraint on the development of rare earth mining and manufacturing in the US concerns intellectual property and know-how. Former Sumitomo, now Hitachi Metals, holds 615 patents on various NdFeB production processes and as of April 2007 they had another 420 patent applications filed and pending. Rare earth magnet production capabilities in countries that enforce patent laws would likely be subject to these patents, associated licenses, and close scrutiny. A list of Hitachi's patents by country can be found in Appendix C.

<u>Potential Rare Earth Gap</u>

These constraints on rare earth mining and manufacturing in the US has led to the aforementioned total dependence on China. However, there appear to be significant concerns regarding China's management of its rare earth assets and the resulting implications for rare earth availability and cost. Ian London of Avalon Ventures reports that "the Chinese economy is expected to consume all of its production [of rare earths] by 2012 – 2014." This point has been repeated by a number of other rare earth and mining experts interviewed.

The consequences of limited availability and higher rare earth costs in the 2012-2014 time-period could be significant, including increased costs to produce electric vehicles, advanced batteries, magnets and many armaments. Measures to expand domestic production or develop substitute materials would likely not be effective in the short term.

Significant Western investments in rare earth mining are not expected over the next five years due to the economic crisis, a shortage of investable capital, and the limitations that have been placed on the production of metals and their by-products in the US due to environmental and other regulations at the local, state and federal levels.

The push for green technologies and industries is a driver of demand for rare earth materials. Increased demand for green technologies may accelerate the apparently emerging rare earth supply chokepoints.

Potential Cobalt Issue

While not a rare earth material, cobalt is used in samarium cobalt magnets and in the cathodes of lithium-ion batteries. In their 2009 Mineral Commodity Summary for cobalt, the USGS reports the US "did not mine or refine cobalt in 2008." The bulk of the world's supply of cobalt ore comes from politically unstable regions like the Congo.

Some sources indicate Canada is the second-largest cobalt producer in the world (with no numbers cited). There are a number of Canadian mining operations that apparently produce cobalt along with other various metals.

However, the Natural Resources Canada web site doesn't show cobalt as a commodity – only gold, silver, zinc, lead, copper, molybdenum, and nickel. Their page titled "Main Minerals and Metals Produced in Canada" omits cobalt, listing aluminum, chrysotile, coal, copper, gold, iron ore, lead, nickel, potash, salt and zinc. Their 2007 minerals yearbook shows 2,900 tons of cobalt were produced in 2006 and projected 3,200 tons production in 2007.

China is moving to the forefront of the cobalt industry, much as they have with rare earths. The USGS reports "China was the world's leading producer of refined cobalt [in 2008], and much of its production was from cobalt-rich ore and partially refined cobalt imported from Congo (Kinshasa). As a result of restrictions on exports of unprocessed cobalt from Congo, the Chinese cobalt industry was expected to develop more domestic and foreign sources of cobalt supply, to invest in African cobalt projects, to increase the recycling of cobalt scrap, to continue to shift its consumption towards more downstream materials, and to consolidate into fewer larger companies." As hybrid and electric vehicles use increasing amounts of cobalt (particularly in the switch to Li-Ion batteries in plug-in hybrid and electric vehicles), this has the potential of becoming a material chokepoint similar to that of the rare earth metals.

4. Requirements for US Industries to Mine/Manufacture These Materials and Magnets

Mark Smith, CEO of Molycorp, described the demise of the U.S. rare earth industry: "[M]ore and more of the rare earth manufacturing supply chain moved from the United States to China, including metal production, alloying, strip casting, magnetic powder production and, ultimately, magnet production." When Molycorp reopened the Mountain Pass facility there were no active rare earth ore mining operations anywhere in the Western Hemisphere.

An historic example of the development of a rare earth magnet in the US is the NdFeB magnet, which was developed through a combined research effort between the Air Force, General Motors and Sumitomo. The Magnaquench company resulted from this effort and manufactured the magnets in Indiana. However, in the early 2000's a Chinese company bought Magnaquench and within two years had relocated the manufacturing equipment to China.

Although Molycorp has a "Mines to Magnets" business plan they are actively pursuing via the joint venture with Arnold Magnetics, they have yet to resume actual mining. Currently the operation is only processing ores which were mined before Mountain Pass was shut down in 1998. Restarting production of rare earth materials and products in the U.S. will require practically rebuilding the industry from the ground up. The timeline will be determined by the pace of capital investments, environmental compliance efforts, and the time needed to rebuild the mining, processing, and production infrastructures. More important than the timeline is the issue of long-term sustainable and competitive operation. Currently, this appears to be unresolved.

According to several sources, under ideal circumstances it takes at least five years for a rare earth mine to deliver quality products. Molycorp should be at full production by approximately 2012. Any other US operations would reach this point by 2014 at the earliest. This underscores the possibility of a Rare Earth Gap in the 2012-2014 time-frame, given the time it takes for new REO deposits to be processed, reduced and manufactured into elements for the rare earth metals market.

5. Potential for Additional (Non-Chinese) Suppliers to Come On-Stream

The world's primary rare earth deposits are in China. After Mountain Pass, the next largest deposits under development are in Australia. However, the Australian companies are now affiliated with Chinese companies.

Recently Australia's Lynas Corporation has suspended operations at Mountain Weld due to lack of financing. Since that point, the China Non-Ferrous Metal Mining Co. attempted to purchase a 52 percent stake in Lynas, and analysts expected that this purchase plus loans from Chinese banks would allow the company to restart operations later this year. The status of this financial decision and the probability that it would go through was unclear at the time of the writing of this report.

In March 2009, East China Exploration & Development Bureau moved to acquire a 25 percent interest in the Australian mining company Arafura. Arafura has also signed an MOU with Inner Mongolia Baotou Steel Rare Earth Hi-Tech Ltd. to "leverage technical expertise, marketing experience, and to pursue global growth opportunities." Arafura has begun pilot plant work at their Nolans Bore project.

Many of the efforts underway to develop new rare earth deposits in the US and Canada are in the exploration and discovery phase. Even if this exploration results in high-yield finds, as noted above it will take years to develop the mines and begin producing ores or oxides. As Jim Kennedy of Wings Enterprises pointed out, "there are no domestic refining capabilities in North America [and therefore] companies would be forced to sell our rare earth oxides to Japan or China," which would still leave the US dependent upon Chinese sources for rare earth metals.

Ian London of Avalon Ventures summed up the situation in a communication with Synthesis:

> Government will... need to coordinate its carbon reduction policy framework in that it may need to consider the practicalities of providing economic drivers and stimulus funding to major equipment modifications and change-outs (to speed development of more energy efficient pumps, motors, etc), better buildings (materials, lighting) and smarter grid technology (which will drive new energy storage technologies) – and *many of these utilize rare earths in their construction* (emphasis added), [and these REs may] not be available. In this vein, government initiatives may need to focus on raw material development projects.

<u>The Search for Alternatives to Rare Earth Metals</u>

The development of alternatives to rare earth metals and magnets could reduce the demand and dependence on rare earth materials. According to Peter Dent of Electron Energy, new research into magnetic materials to find a viable substitute for rare earth magnets has largely centered on making AlNiCo magnets more heat-resistant. Other rare earth magnet research involves attempts at replacing or reducing the need for neodymium and samarium. Last but not least, researchers are working to reduce dysprosium usage as dysprosium prices are increasing.

Appendix A
U.S. Rare Earth Magnet and Mining Companies

US Rare Earth Magnetic Material Producers

Name	URL	Contact	Title	Address	Phone	Email	Product(s)	Manufacturing Capacity
Electron Energy Corp	http://www.electronenergy.com/	Peter Dent	Vice President of Business Development	924 Links Ave. Landisville, PA 17538	717-459-1001	pcd@electronenergy.com	SmCo Magnets	Only U.S. manufacturer of rare earth magnets (SmCo only); no U.S. company manufacturers NdFeB magnets used in hybrid vehicles. Have requested info on total manufacturing capacity and what would be involved in adding production of NdFeB magnets

US Rare Earth Mining/Production

Name	URL	Contact	Title	Address	Phone	Email	Product(s)	Production/ Manufacturing Capacity
Molycorp Chemicals	http://www.molycorp.com/	Keith Delaney	Manager Technology Commercialization	5619 DTC Parkway, Suite 1000 Greenwood Village, CO 80111	303-843-8080	keith.delaney@molycorp.com	Rare earth oxides; rare earth ores	Estimated capacity 10kt by 2011
Primet LLC	http://www.primetcorp.com			1450 E. American Lane, Suite 1220 Schaumburg, IL 60173	(847)517-8620	rareearth@primetcorp.com	Produces and distributes rare earth materials from China	Leshan Primet: Lanthanum or lanthanum-rich RE oxide and compounds - 280 mt/month Cerium or cerium-rich RE oxide and compounds - 370 mt/month Praseodymium Neodymium oxide - 93 mt/month Samarium Gadolinium Europium Concentrate - 7 mt/month Baotou Primet: Cerium, Lanthanum, Praseodymium, Neodymium Metals and Mischmetal - 140 mt/month *(Note: All production figures are for Chinese-based operations.)*
Tombstone Exploration Group	http://www.tombstonemining.com/	Alan Brown	President	1515 Red Top Rd. P.O. Box 1280 Tombstone, AZ. 85638	520.457.3066	abrown@tombstonemining.com	Mining exploration	"Through expansion, the company will acquire new properties, as well as integrate the extraction of precious metals, rare earth and other minerals."
Wings Enterprises	http://www.wingsironore.com/index.html	James Kennedy	Owner	1185 Ross Road St. Louis, MO 63146	(314) 494-1638	jkennedy@wingsironore.com	Iron ore, rare earth oxides	Developing mine with proven reserves of 600,000 mt heavy rare earth ores with expected yield of >12%; production not yet started

Xploracorp	http://www.xploracorp.org/			21 West Colony Place Suite 150 Durham, NC 27705	1-877-846-4949	contact@xploracorp.com	Investors	"A private company designed to offer our investors exposure to substantial opportunities in the Natural Resource sector. Our main focus at this time is energy (coal, natural gas, renewable energy) and minerals/ mining (iron, rare earth metals)."

Canadian Rare Earth Mining/Production

Name	URL	Contact	Title	Address	Phone	Email	Product(s)	Production/ Manufacturing Capacity
Avalon Ventures	http://www.avalonventures.com/	Ian London	Vice President Market Development	#1901 - 130 Adelaide St. W. Toronto, ON M5H 3P5	416- 364-2262	ilondon@avalonventures.com	Mineral exploration and development company with a primary focus on the rare metals	Commissioned pre-feasibility project on Thor Lake property, to be competed in early 2010; planning begin of production in 2013
Eagle Plains Resources Ltd.	http://www.eagleplains.com/	Mike Labach		Suite 200, 16 – 11th Ave. S. Cranbrook, BC V1C 2P1	(250) 426-0749	mgl@eagleplains.com	Explores for precious and rare metals, to include rare earths	Discovered rare earth ores in the Ice River Complex in British Columbia and will begin exploration this summer.
Great Western Minerals Group	http://www.gwmg.ca/	James B. Engdahl	President and CEO	226 Cardinal Crescent Saskatoon, SK S7L 6H8	(306) 659-4500	info@gwmg.ca	Rare earth exploration; mining; subsidiaries Less Common Metals and Great Western Technologies Inc include processing and magnet production facilities.	Currently no production; attempting to position company to become "first vertically integrated rare earth elements producer in North America". Just signed letter of intent with Toyota Tsusho for joint exploration in the Benjamin River and Douglas River properties owned by Great Western.
Quest Uranium Corporation	http://www.questuranium.com/	Peter J. Cashin	President and CEO	1155 University Street Suite 1308 Montreal, Québec H3B 3A7	(514) 878-3551	info@questuranium.com	Primarily explores for uranium but branching out into rare earths. Exploring Strange Lake area in Quebec	Latest discovery estimated to be 4.35% rare earth oxides. No estimates on total production.
Rare Earth One LLC	http://www.ucoreuranium.com/bokan.asp	James McKenzie	President and CEO	Ucore Uranium Inc. 501-2000 Barrington Street Halifax, Nova Scotia Canada, B3J 3K1	(902) 482-5214	info@ucoreuranium.com	Wholly-owned subsidiary of Ucore Uranium Inc. Exploring Bokan Mountain in Alaskan panhandle	Area estimated by USGS to hold 11+ million pounds of uranium as well as tantalum, niobium, and rare earth elements. Area still under exploration.
Rare Element Resources Ltd.	http://www.rareelementresources.com/s/Home.asp	Donald E Ranta	President & CEO	Suite 410 - 325 Howe Street Vancouver, BC V6C 1Z7	(604) 687-3520	don@rareelementresources.com	Conducting rare earth exploration in Bear Lodge, Wyoming	Estimated to be "one of the largest deposits of disseminated rare-earth elements in North America". No estimates on production volume.

Appendix B

Not included in public release of this report.

Appendix C
Listing of Hitachi Metals Patents Covering Sintered NdFeB Magnets
(As of March 2007)

Japanese patent numbers (181 patents)

1881650 2036488 2064341 2107896 2110977 2132474 2551797 2571403 2599753
2606904 2631492 2631493 2665590 2693601 2720038 2720039 2720040 2731150
2731337 2741508 2745042 2751109 2754098 2789269 2791470 2823076 2840998
2844269 2844270 2859517 2883144 2886378 2886384 2898463 2908637 2922535
2922614 2928494 2935376 2941446 2948223 2954816 2960629 2966342 2986598
2989178 2989420 3001876 3009687 3009804 3020717 3029711 3037699 3047239
3078633 3080275 3083963 3096105 3116885 3120080 3128993 3132393 3135120
3135174 3148573 3148581 3151087 3151088 3157660 3157661 3159693 3160274
3170156 3171415 3171426 3172521 3174442 3174443 3174448 3176597 3180331
3182142 3184355 3187396 3192642 3193912 3193916 3209380 3213157 3218028
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