Rare Earth Elements:
World Demand & Project Status in N.M.

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New Mexico Energy, Minerals and Natural Resources Department

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REE Composition and Geology

• **Rare earth elements ("REEs")**
  – 17 chemical elements: 15 lanthanides plus scandium and yttrium.
  – LREE = light rare earth elements
    • (Sc, La, Ce, Pr, Nd, Pm, Sm, Eu, and Gd; also known as the cerium group)
  – HREE = heavy rare earth elements
    • (Tb, Dy, Ho, Er, Tm, Yb, Lu, and Y; also known as the yttrium group)

• **REE Abundance**
  – Despite their name, REE’s are *relatively plentiful* in the Earth's crust, with cerium being the 25th most abundant element at 68 parts per million (similar to copper).

  However...

• **REE Deposits**
  – *Rare earth elements are typically dispersed* and not often found in concentrated and economically exploitable forms.
  – Economically exploitable deposits called “rare earth minerals”
Rare Earths & Advanced Metals

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- **LREE**: La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu
- **HREE**: Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr

**Rare earths/metals & related**

**Advanced metals**
Rare Earth Minerals

Monazite – a phosphate
Ce variety: (Ce, La, Pr, Nd, Th, Y)PO₄
La variety: (La, Ce, Nd, Pr)PO₄
Nd variety: (Nd, La, Ce, Pr)PO₄
Pr variety: (Pr, Nd, Ce, La)PO₄

Target Mineral in Petaca Mining District, NM

Bastnäsite – a fluorcarbonate:
Ce variety: (Ce, La)CO₃F
La variety: (La, Ce)CO₃F
Y variety: (Y, Ce)CO₃F

Target Mineral in Cornudas Project, NM
U.S. REE Deposits
New Mexico REE Occurrences

- Known deposits containing high concentrations of REEs, by Mining District
- Resource potential identified as “inferred.” Economically viable?
- Exploration/research
Common Uses for REE’s

• Superconductor Magnets & Capacitors
  – Wind turbines
• Special Steels & Alloys
• Glass, Ceramics & Refractories
• Solar Panels
• Electronics
  – Flat Panel Displays (cell phones, DVDs, laptops)
  – Fiber Optic Telecommunications
• Lasers & Medical Equipment
• Hybrid/Electric Cars
• Automobile & Petroleum Refining Catalysts
• National Defense Applications
  – Precision-guided missiles
  – Smart bombs
  – Aircraft
Hybrid Auto Transportation – Multi metals
Advanced metal uses
Advanced Metals and our Military

RARE EARTH USES IN THE MILITARY

Chromium, Titanium

Beryllium

Beryllium, Niobium

Lanthanum, Gadolinium, Yttrium

Neodymium

Scandium

Lanthanum, Cerium
Strategic and Critical Metals

• **New Demands for Strategic and Critical Metals**
  – World demand ~136,000 tons per year
  – Global production ~133,600 tons per year (2010). The difference is covered by previously mined aboveground stocks.
  – World demand projected to rise to at least 185,000 tons annually by 2015.

• **Critical and strategic metals driving “green & strategic technologies”**
  – 15 metals and minerals with the greatest supply risk to the US economy: antimony, barite, chromite, cobalt, fluorspar, gallium, graphite, indium, niobium, platinum group metals, REE, rhenium, tantalum, titanium, and tungsten (USGS 2010)
  – Obama Administration announced the filing of a World Trade Organization case against China, citing unfair trade practices in REE (March 2012)

• **Future Long Term Supply of Critical Metals from Where?**
  – “The United States was once self-reliant in domestically produced REEs, but over the past 15 years has become 100% reliant on imports, primarily from China, because of lower-cost operations.”
  – Molycorp Mountain Pass in California projected to re-start 4th quarter 2012. Only mine in US with proven reserves (1.1 million metric tons)

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U.S. Imports & Chinese Dominance

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REE Mining in New Mexico

• To date, MMD has processed 12 REE-related exploration permit applications in N.M.
• Exploration Projects located in Rio Arriba, Lincoln, Socorro and Otero Counties.
• Currently 4 are active permits:
  – Cornudas Project in Otero Co.
  – General Permit (small) in Rio Arriba Co.
  – Two exploration permits in Lincoln Co.
Mine Project Development

• **Prospecting**
  – Identify location
  – Land ownership issues

• **Exploration**
  – Performed iteratively/phased
  – Prove-up the resources

• **Process Development**
  – Metallurgical analysis

• **Feasibility Studies**
  – Conceptual mine plan
  – Preliminary economic feasibility
  – Pilot test (metallurgical process)
  – Optimal mine plan/engineering
  – Definitive economic feasibility

• **Permitting**
  – Environmental impact analysis
  – Plan of operations

• **Construction**
  – Costs/financing
  – Time/contracts/bids

• **Operation/Production**
Obstacles

• **Financing/Capital**
  – Molycorp Mountain Pass investing $500M to reopen and expand
  – New mines are all capital expenditures with no revenue

• **Environmental Concerns:**
  – Cornudas Project (New Mexico)
    • Located within Otero Mesa (sensitive area; intense public interest/opposition)
  – Milling process & waste stream
    • Molycorp Mountain Pass Mine est. 600,000 gallons of radioactive and other hazardous waste discharged through leaks and spills

• **Time**
  – Permit-explore-develop feasibility studies
  – Permitting (years)
  – Litigation