The Principal Types of Rare Earth Elements Deposits

Mountain Pass mine, California
*MP Materials*

Mountain Pass mine, California
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Bokan Mountain, Alaska
*Ucore Rare Metals*
Rare Earth Elements (REEs) deposit types

- Carbonatites (global light rare earth source)
- “South China clays” (global heavy rare earth source)

- Alkaline igneous intrusions
  - Vein deposits
  - Layered alkaline intrusions
- Magmatic iron bodies
- Coastal sand deposits
- Sedimentary phosphate deposits
**Carbonatite**: A rare igneous **carbonate** rock containing 50 percent or more carbonate minerals.

**Sulphide Queen carbonatite**
(Mountain Pass deposit)

- REE oxide content of 7.98 percent
- Dominantly light REEs
Mountain Pass processing facilities on-site
Longnan, China

“South China clays”

0.03 to 0.5 % total REE oxide

The Telegraph, March 2012
Bokan Mountain alkaline igneous intrusive complex
- 5.8 million metric tons of mineable resource
- avg. grade of 0.6% total REE oxide
- ~ 40% heavy REE
Layered alkaline igneous intrusions

Map of North America showing locations of Nechalacho, Ilimaussaq, Strange Lake, and Kipawa/Zeus.
Magmatic magnetite-hematite (iron) bodies

- Pea Ridge iron mine, southeastern Missouri
- Mineville iron mining district, upstate New York
Mineville iron mining district, northeast New York, active 1804 - 1971

Large iron tailings piles

2/3 of tailings from apatite-rich ores

Represents ~9 million metric tons of tailings

Average grade of ~8% apatite

~726,000 metric tons of apatite in tailings

Apatites average 11.14% REE oxide

~80,700 metric tons of REE oxide
Coastal deposits of Heavy-Mineral Sands

- Ilmenite: $\text{Fe}^{2+}\text{TiO}_3$
  - Most abundant heavy mineral

- Rutile: $\text{TiO}_2$
  - 2nd most

- Zircon: $\text{ZrSiO}_4$
  - 3rd most

- Monazite: $(\text{REE, Th})\text{PO}_4$
  - Trace to minor amounts of heavy mineral suite
Phosphorite

Phosphate-rich layers formed by the evaporation of sea water
Critical mineral resources of the United States
Google: “USGS Professional Paper 1802”

The principal rare earth elements deposits of the United States
Google: “USGS SIR 2010-5220”

Rare earth element mineral deposits in the United States
Google: “USGS Circular 1454”

Rare earth elements in coal and coal fly ash
Google: “USGS Fact Sheet 2019-3048”

Earth MRI Initiative
Google: “USGS Earth MRI”