CRITICAL & STRATEGIC MINERALS IN SOUTHWEST COLORADO

Information with Permission From

Jim Burnell, Colorado Geological Survey
“Critical and Strategic Minerals”
“Can Colorado Play a Role?”

Todd Hennis, Green Energy Metals Corp.
“San Juan County’s Future and Its”
“Critical Importance to the United States”
HISTORIC MINERALS PRODUCED IN SOUTHWEST COLORADO

Gold
Silver
Lead
Copper
Zinc
Molybdenum
Uranium
Vanadium
Accessory Minerals Produced Historically Or Recovered As By-Products

Antimony
Fluorspar
Magnesium
Manganese
Tungsten
Demand Has Been Created For

- Indium
- Gallium
- Germanium
- Tantalum
- Tellurium
- Platinum Group
- Rare Earths
- & Others
Various applications of Critical and strategic minerals

Transport
- Aluminum
- Antimony
- Graphite
- Platinum Group
- Manganese
- Nickel

Packaging
- Aluminum
- Tin

Construction
- Aluminum
- Manganese
- Titanium
- Vanadium

Medical
- Arsenic
- Barium
- Cesium
- Titanium

Energy (various)
- Aluminum
- Barium
- Cesium
- Molybdenum
- Platinum Group
- Rare Earths

Chemical
- Antimony
- Fluorine
- Magnesium
- Nickel
- Platinum Group
- Rhenium

Electrical/Electronic
- Arsenic
- Gallium
- Indium
- Sheet mica
- Platinum Group
- Tantalum
- Germanium
- Tin
- Silver
- Rare Earths
- Tellurium
- Vanadium

Alternative Energy
- Cobalt
- Lithium
- Nickel
- Rare Earths
- Vanadium
- Indium
- Germanium
- Gallium
- Graphite
- Selenium
- Silver
- Tellurium
- Vanadium

Machinery
- Aluminum
- Cobalt
- Manganese

Manufacturing
- Aluminum
- Cobalt
- Lithium
- Nickel
- Rare Earths
- Graphite
- Indium
- Magnesium
- Nickel

Ceramics/Glass
- Antimony
- Fluorine
- Lithium

Defense/Aerospace
- Cobalt
- Nickel
- Niobium
- Rare Earths
- Rhenium
- Vanadium
Alternative Energy Metals

Gallium
Gallium Applications

Light-emitting diodes (LEDs)

Power amplifiers for cell phones

Photovoltaic Material – CIGS (Copper Indium Gallium Selenium)
Germanium
Some Applications of Germanium

- Fibre optics and infrared optics
- Hi-speed silicon-germanium integrated circuits
- PET Plastics
- Low-reflectivity industrial glass
- Aluminum & beryllium alloys
Indium
Some Indium Applications

Copper Indium Gallium diSelenide photovoltaic cells (CIGS)

Indium Tin Oxide (ITO) used for Liquid Crystal Displays (LCDs), flat panel displays, optical coatings, light-emitting diodes (LEDs), antistatic coatings, strain gauges, gas sensors.
Tellurium noted for its propensity to combine with gold to form gold telluride minerals.
Some Tellurium Applications

Copper and Stainless Steel alloys

Vulcanizing rubber

New flash memory devices of Germanium-Tellurium-Antimony

Cadmium-Tellurium thin-film photovoltaic technology
Colorado Zinc Deposits
Indium, gallium, germanium all can be found in zinc deposits within Colorado Within Southwest Colorado
Alternative Energy+Defense

Tantalum

Niobium
Tantalum

- Capacitors
- Jet engines/
  Rocket assemblies
- Surgical implants

Uses

Niobium

- Superconducting magnets
- Structural Steel
Vanadium
Some Vanadium Applications

Aerospace applications of tin-vanadium alloys

Impact-resistant steel for construction, armor plating, automobile parts.

Superconducting magnets, ceramics, catalysis
Alternative Energy

Vanadium flow battery – utility scale;

Vanadium is showing promise to improve performance of Lithium-ion batteries for electric vehicles.

One firm is marketing a wind power generation transmission and storage system of V-based alloy.
Rare Earths
and the Platinum Group
Platinum Group Metals - PGM

Platinum    Osmium
Palladium   Iridium
Ruthenium   Rhodium

Petroleum-refining catalysts
Catalytic converters
Hard disk drives
Hi-temp applications
Jewelry & bullion
Fiberglass manufacture
Spark plug tips
Rare Earth Elements - REE

17 of ‘em

A Few Uses:

permanent NdFeB magnets for many uses
(up to a ton per MW in wind turbines generators)

numerous defense applications including

• precision guided munitions
• lasers
• klystrons and traveling wave tubes
• aircraft electrical systems and displays
• radar systems
• electronic counter measures systems
• and more.

Hybrid car batteries
  glass
  ceramics
  catalysis
  lighting
  fuel cells
  electrodes
# REE 2013 Projections

<table>
<thead>
<tr>
<th></th>
<th>Supply</th>
<th>Demand</th>
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<tbody>
<tr>
<td>Lanthanum</td>
<td>54,000 t/yr</td>
<td>59,000 ton/yr</td>
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<tr>
<td>Neodymium</td>
<td>39,500 t/yr</td>
<td>36,000 ton/yr</td>
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China is expanding manufacturing to use up their supply, including Nd-Fe-B magnets for wind turbine generators.

Prediction: China will use all they mine internally in 2 years.
REE-PGM Occurences

Explanation

- Known Zinc Occurrence (potential Ga, Ge, In)
- REE Potential Rare Earth Element
- PGM Potential Platinum Group Metals
Largest Known Resource of Titanium And Niobium in the United States

722.7 million tons of carbonatite

0.397% total rare earth (RE) oxides = 2.87 M tons of RE oxides

0.0043% ThO$_2$ = 31,080 tons of ThO$_2$

0.057% Nb$_2$O$_5$ = 412,000 tons of Nb$_2$O$_5$

*From Staatz and others (1979)*
Large sample of ore containing molybdenite from Henderson Mine, Clear Creek County
Uses

Nuclear reactor vessels. Tubing in nuclear plants and desalination plants.

New generation of double-hulled oil tankers. Oil and gas pipelines. Drill steel for oil drilling.

Scrubbers in coal-fired power plants. Rocket engine components.
Additional Uses of Molybdenum

Chrome-Moly Bike Frame

Chrome-Moly Tubing in Aircraft

Chrome-Moly Tubing in Toboggan
Colorado Molybdenum:
Possibility of four large primary molybdenum mines:
- Henderson, Climax, Mount Emmons, and Rico

U.S. maintains role as net exporter of Molybdenum
The demand from newly developing countries is impacting the supply and price of critical and strategic minerals.

The U.S. needs a ready supply of these commodities to maintain leadership in existing technologies and establish leadership in emerging technologies.

Deposits of Critical & Strategic minerals are known to exist in the Historic Mining Districts of Colorado.

With public support, these deposits can be located and mined responsibly.