Business Executives for National Security

BENS Critical Minerals Series

About the BENS US Critical Minerals List Criticality Ranking

The factors underpinning the criticality of the 35 minerals identified by the U.S. Geological Survey (USGS) in 2018 to the economic and national security of the United States vary considerably. Those factors include:

- the extent to which the United States relies on imports of these minerals;
- the country exporting the minerals to the United States;
- the availability of mitigation possibilities, including substitute minerals, and;
- critical mineral end uses in vital U.S. industries.

As the USGS states in its explanation of the list's methodology, developing a criticality chart simplifies a complex issue, and no single method will meet the need for all stakeholders with an interest in identifying the most critical. The Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals tasks the USGS with prioritizing the minerals in its list, but a USGS official indicated in a March 2020 phone call that this has not yet happened. BENS therefore developed a criticality scoring system in order to better understand and convey differences in some of the key factors behind the criticality of these 35 minerals. The BENS system rated them on a zero to 10 scale, with 10 being the most "critical," or vulnerable to disruption.

Net Import Reliance. The net import reliance scale ranges from zero to three: a three reflects minerals for which the United States depends on imports to fulfill 100% of domestic demand; a two reflects a U.S. import reliance of 75-99%; a one reflects U.S. import reliance of 50-74%, and a zero reflects an import reliance of below 50%.

Import Source Dependency. BENS also rated the minerals based on the sources of U.S. imports, and the degree of reliance the United States has on those sources, on a scale of zero to three. Given China's dominant role in the supply chains for many of the critical minerals, those for which the United States imports 50% or more from China received a three. If a single country that does not belong to the Organization for Economic Cooperation and Development (OECD) accounts for 50% or more of U.S. imports, that mineral received a two. A one was assigned to minerals for which the United States imported 50% or more from a single OECD country. If the United States did not rely on any single country for 50% or more of its imports, that mineral received a zero.

Mitigation Opportunities. Substitutes for each mineral were rated from zero to two points. Minerals that have no substitutes were delegated two points. One point was given to minerals whose substitutes are also found on the USGS' list of critical minerals. Minerals that have multiple substitutes not included on the USGS list were assigned a zero.

Siginificance of End Uses and Industries. The end uses and industries for which the minerals are essential are also rated from zero to two points. Minerals necessary for defense industries were designated two points. Those important for non-defense aerospace and energy uses received a one. Minerals integral to all other sectors (identified by the USGS as telecommunications and electronics, transportation, and other) were assigned a zero.

The BENS US Critical Minerals List Criticality Ranking

	Mineral	Criticality Score	U.S. Net Import Reliance (and Score)	Major Import Sources and % of Import (and Score)	Primary U.S. Industry End Uses (and Score)	Mitigation Opportunities (and Score)
1	Rare Earths	10	100% (3)	China (80%), Estonia (6%), France (3%), Japan (3%) – (3)	Batteries and electronics – (2)	Substitutes are available for many applications but are generally less effective. (2)
2	Scandium	10	100% (3)	no percentages available - majority from China (3)	Alloys and fuel cells – (2)	Titanium and aluminum high-strength alloys and carbon-fiber (2)
3	Niobium	9	100% (2)	Brazil (72%), Canada (18%), Russia (3%), Germany (2%) – (2)	Steel alloys, jet engines – (2)	Ceramic matrix composites, molybdenum, tantalum, tungsten, titanium, vanadium (2)
4	Bismuth	9	96% (3)	China (80%), Belgium (8%), Mexico (4%), Republic of Korea (2%) – (3)	Medical and atomic research – (2)	Pharmaceutical: alumina, antibiotics, calcium carbonate, magnesia; Pigment: titanium dioxide-coated mica flakes and fish scale extracts; Low temperature solders: cadmium, indium, lead, and tin; Machining: resin, lead, selenium, or tellurium (2)
5	Antimony	9	85% (3)	China (61%), Thailand (11%), Belgium (10%), Bolivia (8%) – (3)	Batteries, flame retardants – (2)	Flame retardants: organic compounds and hydrated aluminum oxides Enamels, paint, and pigments: chromium, tin, titanium, zinc, zirconium Lead-acid batteries: calcium, copper, selenium, sulfur, and tin (2)
6	Manganese	8	100% (3)	South Africa (26%), Gabon (21%), Australia (14%), Georgia (11%) – (0)	Steelmaking, jet engines, land-based turbines – (2)	None (3)
7	Rubidium	8	100% (3)	no percentages available - majority from Canada (1)	GPS, guidance systems, and electronics – (2)	Cesium (2)
8	Cesium	8	100% (3)	no percentages available - majority from Canada (1)	GPS, guidance systems, night vision devices, cellular phones, motion sensors, fiber optics – (2)	Rubidium (2)
9	Arsenic	8	100% (3)	Morocco (50%), China (47%), Belgium (3%) – (2)	Lumber preservatives, pesticides, semi-conductors, cellular phones – (2)	Wood treatment: alkaline copper quaternary, ammoniacal copper quaternary, ammoniacal copper zinc arsenate, alkaline copper quaternary boron-based preservative (1)
10	Tellurium	7	>75% (2)	Canada (66%), China (27%), Germany (3%) – (1)	Steelmaking and solar cells, night vision – (2)	Bismuth, calcium, lead, phosphorus, selenium, and sulfur (2)
11	Gallium	7	100% (3)	China (32%), United Kingdom (28%), Germany (15%), Ukraine (14%) – (0)	Integrated circuits and optical devices (LEDs), cellular phones – (2)	LEDs: liquid crystals; Mid-tier 3G Cellular Handsets: silicon-based complementary metal-oxide semiconductor power amplifiers; Laser Diodes: indium phosphide compounds, helium-neon lasers; Solar-cells: silicon (2)

12	Strontium	7	100% (3)	Mexico (86%), Germany (12%), China (2%) – (1)	Pyrotechnics and ceramic magnets – (2)	Barium (1)
13	Tantalum	7	100% (3)	Brazil (35%), Rwanda (31%), Australia (15%), Congo (Kinshasa) (8%) – (0)	Electronic components (capacitors), jet engines, aircraft components – (2)	Carbides: niobium and tungsten; Electronic capacitors: aluminum, ceramics, niobium; Corrosion-resistant applications: glass, molybdenum, nickel, niobium, platinum, stainless steel, titanium, zirconium; High-temperature applications: hafnium, indium, molybdenum, niobium, rhenium, tungsten (2)
14	Vanadium	7	100% (3)	Austria (34%), Canada (22%), Republic of Korea (16%), Russia (13%) – (0)	Titanium alloys, jet engines, grid scale batteries – (2)	Manganese, molybdenum, niobium (columbium), titanium, and tungsten, are to some degree interchangeable with vanadium as alloying elements in steel. (2)
15	Potash	7	92% (2)	Canada (84%), Russia (7%), Belarus (3%), Israel (3%) – (1)	Fertilizer, oil and gas drilling fluid – (1)	None (3)
16	Lithium	7	>50% (1)	Argentina (51%), Chile (44%), China (3%), Russia (1%) – (2)	Batteries – (2)	Batteries, ceramics, greases, glass: calcium, magnesium, mercury, zinc, aluminum (2)
17	Barite	7	84% (2)	China (63%), India (14%), Mexico (11%), Morocco (10%) – (3)	Oil and gas drilling – (1)	Drilling mud: celestite, ilmenite, iron ore, and synthetic hematite (1)
18	Germanium	7	>50% (1)	China (58%), Belgium (26%), Germany (7%), Russia (6%) – (3)	Fiber optics and night vision applications – (2)	Electronics: silicon (1)
19	Rhenium	6	84% (2)	Chile (85%), Germany (6%), Belgium (4%), Poland (3%) – (1)	Jet engines, petroleum catalysts – (1)	Indium and tin (2)
20	Fluorspar	6	100% (3)	Mexico (69%), Vietnam (10%), South Africa, (8%) China (6%) – (1)	Manufacture of aluminum, gasoline, and uranium fuel – (1)	Fluorspar fluxes: aluminum smelting dross, borax, calcium chloride, iron oxides, manganese ore, silica sand, titanium dioxide (1)
21	Graphite (natural)	6	100% (3)	China (37%), Mexico (29%) Canada (17%), Brazil (9%) – (0)	Lubricants, batteries, and fuel cells, jet engine components – (2)	Synthetic graphite powder, calcined petroleum coke, Molybdenum (1)
22	Indium	6	100% (3)	China (27%), Canada (22%), Republic of Korea (11%), Taiwan (10%) – (0)	LCD screens, aircraft wind shield, lasers – (2)	LCDs: antimony tin oxide; Flexible displays, solar cells, touch screens: carbon nanotube, PEDOT, copper, silver; Nuclear reactor control rod alloys: hafnium (1)
23	Tin	6	78% (2)	Indonesia (23%), Malaysia (23%), Peru (22%), Bolivia (17%) – (0)	Protective coatings and alloys for steel – (2)	Aluminum, glass, paper, plastic, or tin-free steel, aluminum alloys, copper-base alloys, and plastics for bronze (2)
24	Titanium (sponge metal)	6	75% (2)	Japan (81%), Kazakhstan (7%), Ukraine (7%), China (3%) – (1)	White pigment or metal alloys, jet engines, artillery, airframes – (2)	Aluminum, intermetallics, steel, super-alloys, nickel, zirconium (1)
25	Chromium	6	71% (1)	South Africa (36%), Kazakhstan (10%), Russia (7%) – (0)	Stainless steel and alloys, jet engines – (2)	None (3)
26	Aluminum (Bauxite)	5	50% (1)	Canada (51%), Russia (9%) – (1)	Airframes, fuselage, aerospace, naval vessels, ground vehicles, power transmission lines, lightweight alloys, land-based turbines, marine vessels – (2)	Packaging: glass, paper, plastics, and steel; Aircraft fuselages and wings: composites; Ground transportation: components, magnesium, steel (1)

27	Hafnium	5	>50% (1)	Germany (47%), France (30%), United Kingdom (11%), China (11%) – (0)	Nuclear control rods, alloys, high-temperature ceramics – (2)	Silver-cadmium-indium, zirconium (2)
28	Magnesium (metal)	5	<25% (1)	Israel (27%), Canada (22%), United Kingdom (10%) – (0)	Furnace linings for manufacturing steel and ceramics – (2)	Aluminum and zinc (2)
29	Uranium	5	>95% (2)	Canada (24%), Kazakhstan (20%), Kazakhstan (18%) Russia (13%) (source U.S. EIA) –(0)	Nuclear fuel, space missions – (2)	Thorium (and clean energy sources such as solar power and natural gas) (1)
30	Beryllium	4	<24% (1)	Kazakhstan (44%), Japan (14%), Brazil (7%) – (0)	Alloying agent for aerospace and defense, guidance systems, radar, undersea cable housings – (2)	Metal matrix, organic composites, pyrolytic graphite, silicon carbide, steel, titanium (1)
31	Cobalt	4	61% (1)	Norway (18%), China (12%), Japan (12%), Finland (9%) – (0)	Rechargeable batteries and superalloys for jet engines – (2)	Lithium-ion batteries: nickel; Magnets: strontium ferrites, neodymium-iron-boron, nickel-iron alloys; Paints: cerium, iron, lead, manganese, vanadium; Diamond tools: cobalt-iron-copper or iron-copper; Cutting and wear-resistant materials: iron, iron-cobalt nickel, nickel, cements, or ceramics; Jet engines: nickel-based alloys or ceramics; Petroleum catalysts: nickel (1)
32	Tungsten	4	50% (1)	China (32%), Bolivia (9%), Germany (9%), Canada (8%) - (0)	Wear-resistant metals, jet engines, cellular phones, oil and gas drilling equipment – (2)	Cemented carbides based on molybdenum carbide, niobium carbide, or titanium carbide; ceramics; ceramic-metallic composites (1)
33	Helium	3	Net exporter (0)	Qatar (79%) - (0)	MRIs, lifting agent, and semiconductors – (0)	None (3)
34	Zirconium	3	Net exporter (0)	South Africa (55%), Australia (23%), Senegal (18%) - (0)	High-temperature ceramics, jet engines, incendiaries, nuclear applications – (2)	Foundry: chromite and olivine; Nuclear: niobium (columbium), stainless steel, tantalum; Super-alloys: hafnium; High-temperature applications: dolomite and spinel (1)
35	Platinum Group Metals	3	73% (1)	South Africa (44%), Germany (15%), United Kingdom (10%), Italy (7%) - (0)	Catalytic agents, jet engines, hard-disk drives – (1)	Palladium (1)

This information was produced by the BENS Resilience Council to raise awareness of the vulnerabilities to U.S. access to critical minerals and to stimulate action for bolstering reliable supply to these essential resources. For more information on the BENS Resilience Council and their efforts, contact Sean Withington at SWithington@bens.org.