

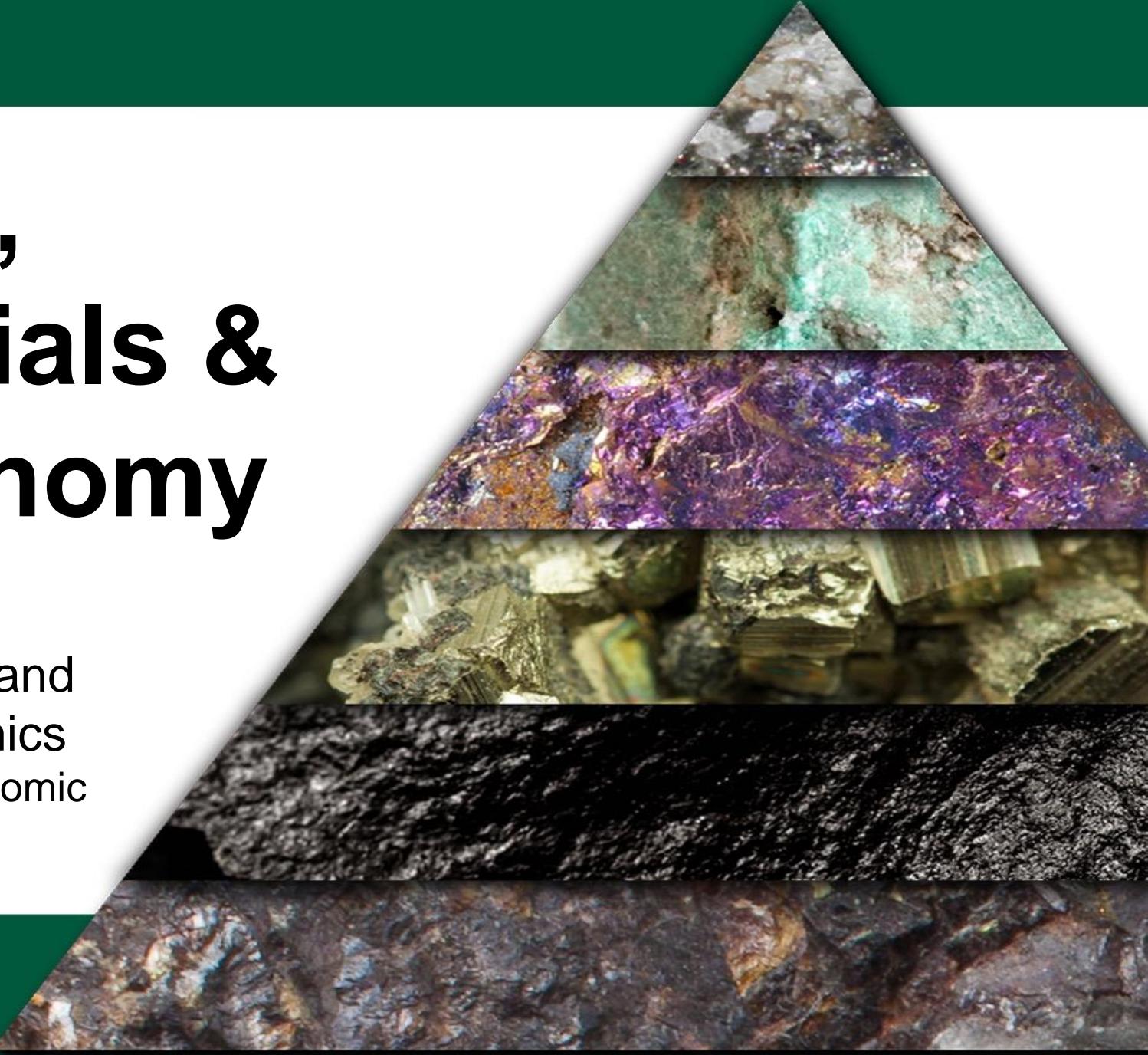
# Minerals, Critical Materials & Alaska's Economy

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# Defining “Critical Minerals”

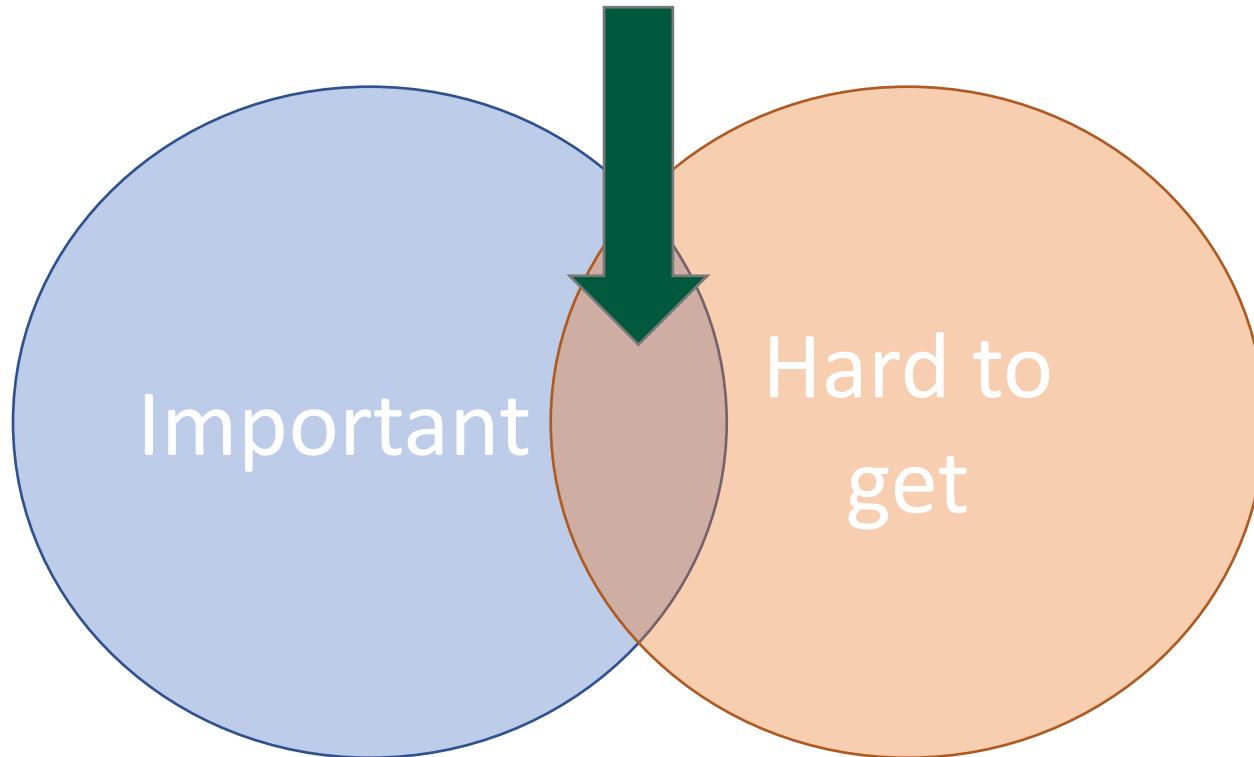
1 IA 1A	1 H Hydrogen 1.008	2 IIA 2A	18 VIIIA 8A
3 Li Lithium 6.941	4 Be Beryllium 9.012	13 IIIA 3A	2 He Helium 4.003
11 Na Sodium 22.990	12 Mg Magnesium 24.305	5 B Boron 10.811	10 Ne Neon 20.180
19 K Potassium 39.098	20 Ca Calcium 40.078	6 C Carbon 12.011	17 VIIA 7A
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	7 N Nitrogen 14.007	1 F Fluorine 18.998
55 Cs Cesium 132.905	39 Sc Scandium 44.956	8 O Oxygen 15.999	10 Ne Neon 20.180
87 Fr Francium 223.020	40 Ti Titanium 47.88	14 VA 5A	18 Ar Argon 39.948
88 Ra Radium 226.025	21 V Vanadium 50.942	15 VI 6A	19 Kr Krypton 84.80
89-103	22 Cr Chromium 51.996	16 VII 7A	30 Se Selenium 78.09
104 Rf Rutherfordium [261]	23 Mn Manganese 54.938	17 IB 1B	31 Br Bromine 79.904
105 Db Dubnium [262]	24 Fe Iron 55.933	18 IIB 2B	32 Kr Krypton 84.80
106 Sg Seaborgium [266]	25 Co Cobalt 58.933	19 IIIB 3B	33 As Arsenic 74.922
107 Bh Bohrium [264]	26 Ni Nickel 58.693	20 IVB 4B	34 Se Selenium 78.09
108 Hs Hassium [269]	27 Cu Copper 63.546	21 VB 5B	35 Br Bromine 79.904
109 Mt Meitnerium [268]	28 Zn Zinc 65.39	22 VIB 6B	36 Kr Krypton 84.80
110 Ds Darmstadtium [269]	29 Ga Gallium 69.732	23 VIIIB 7B	37 Rb Rubidium 84.468
111 Rg Roentgenium [272]	30 Ge Germanium 72.61	24 VII 8	38 Sr Strontium 87.62
112 Cn Copernicium [277]	31 As Arsenic 74.922	25 VII 8	39 Y Yttrium 88.906
113 Uut Ununtrium unknown	32 Se Selenium 78.09	26 VII 8	40 Zr Zirconium 91.224
114 Fl Flerovium [289]	33 Ge Germanium 72.61	27 VII 8	41 Nb Niobium 92.906
115 Uup Ununpentium unknown	34 Br Bromine 79.904	28 VII 8	42 Mo Molybdenum 95.94
116 Lv Livermorium [298]	35 Po Polonium [208.982]	29 VII 8	43 Tc Technetium 98.907
117 Uus Ununseptium unknown	36 At Astatine 209.987	30 VII 8	44 Ru Ruthenium 101.07
118 Uuo Ununoctium unknown	37 Rn Radon 222.018	31 VII 8	45 Rh Rhodium 102.906
Lanthanide Series			
57 La Lanthanum 138.906	58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24
58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913
59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36
60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966
61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25
62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925
63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50
64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930
65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26
66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934
67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04
68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
Actinide Series			
89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029
90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048
91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064
92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061
93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070
94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070
95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080
96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]
97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095
98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1
99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101
100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

# Defining “Critical Minerals”

- Critical minerals are *IMPORTANT* and also *HARD TO GET*

Consequence of Disruption

- Manufacturing Supply chains = Lost GDP



Probability of Disruption

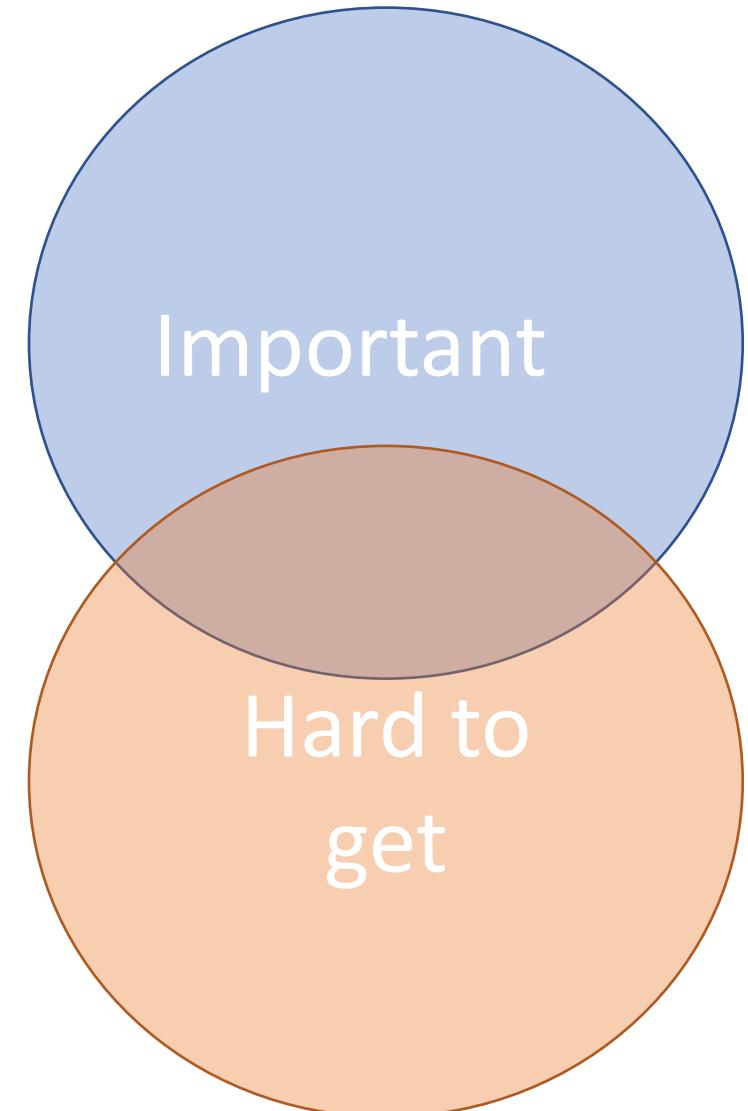
- Concentrated production
- Market volatility
- Competition from other users
- Bottlenecks

# What's “Critical” Depends on Your Perspective

- At a country level: The *US*’s manufacturing industry has a different perspective than *Germany*’s
  - We make different things
  - We have different supply chains
- At a company level: *Tesla* different than *Toyota*
  - Tesla only makes EVs
  - Toyota makes ICE, hybrid, and EVs
- *China*’s supply risk is different than the *UK*’s
  - China dominates secondary processing
  - BUT still faces risks

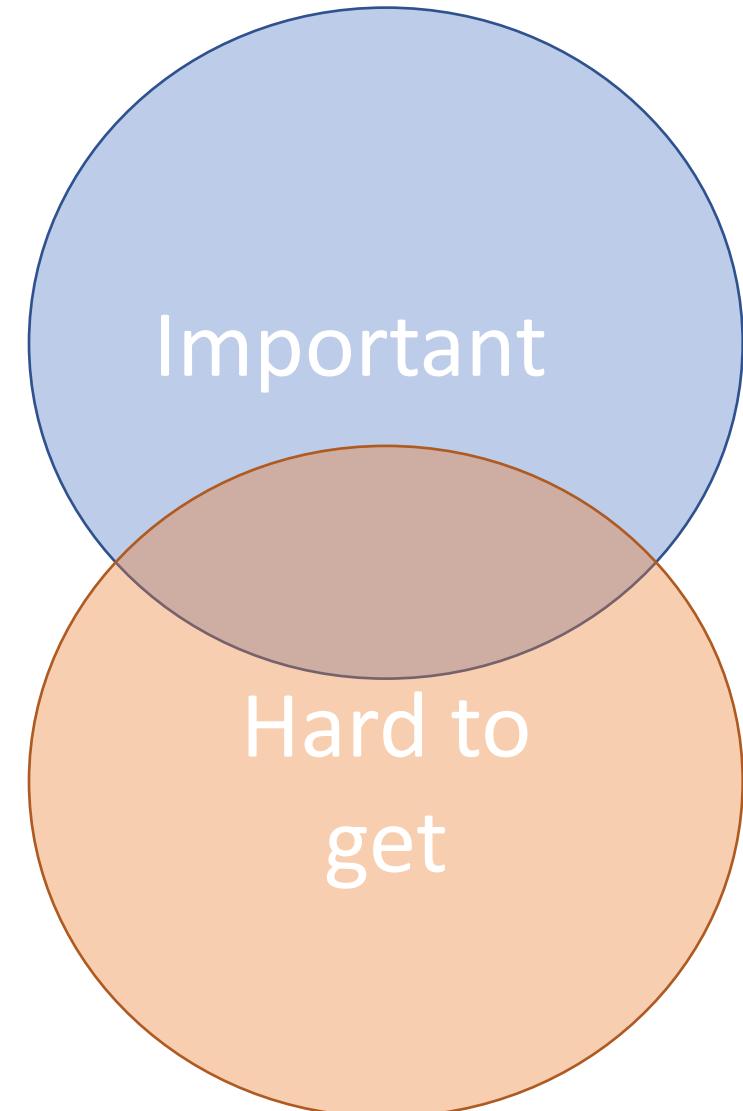
# A look at one perspective: USGS

- USGS in 2018 released list of “critical” minerals in response to Executive Order No. 13817
- The Energy Act of 2020 now requires USGS to update method and list every 3 years.
  - Critical minerals defined as minerals which:
  - (i) are essential to the economic or national security of the United States;
  - (ii) the supply chain of which is vulnerable to disruptions (including restrictions associated with foreign political risk, abrupt demand growth, military conflict, violent unrest, anti-competitive or protectionist behaviors, and other risks throughout the supply chain); **and**
  - (iii) serve an essential function in the manufacturing of a product (including energy technology-, defense-, currency-, agriculture-, consumer electronics-, and healthcare-related applications), the absence of which would have significant consequences for the economic or national security of the United States”



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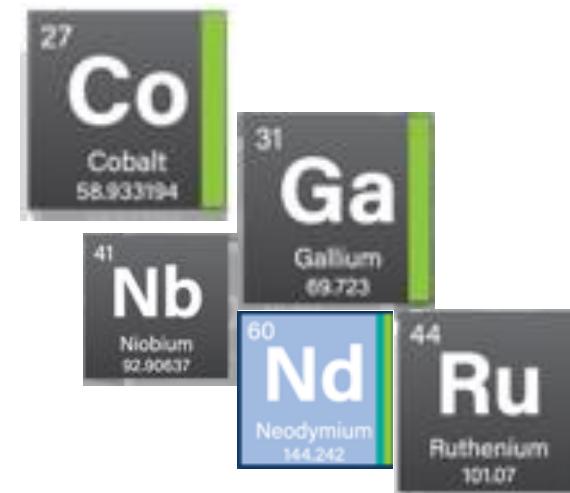
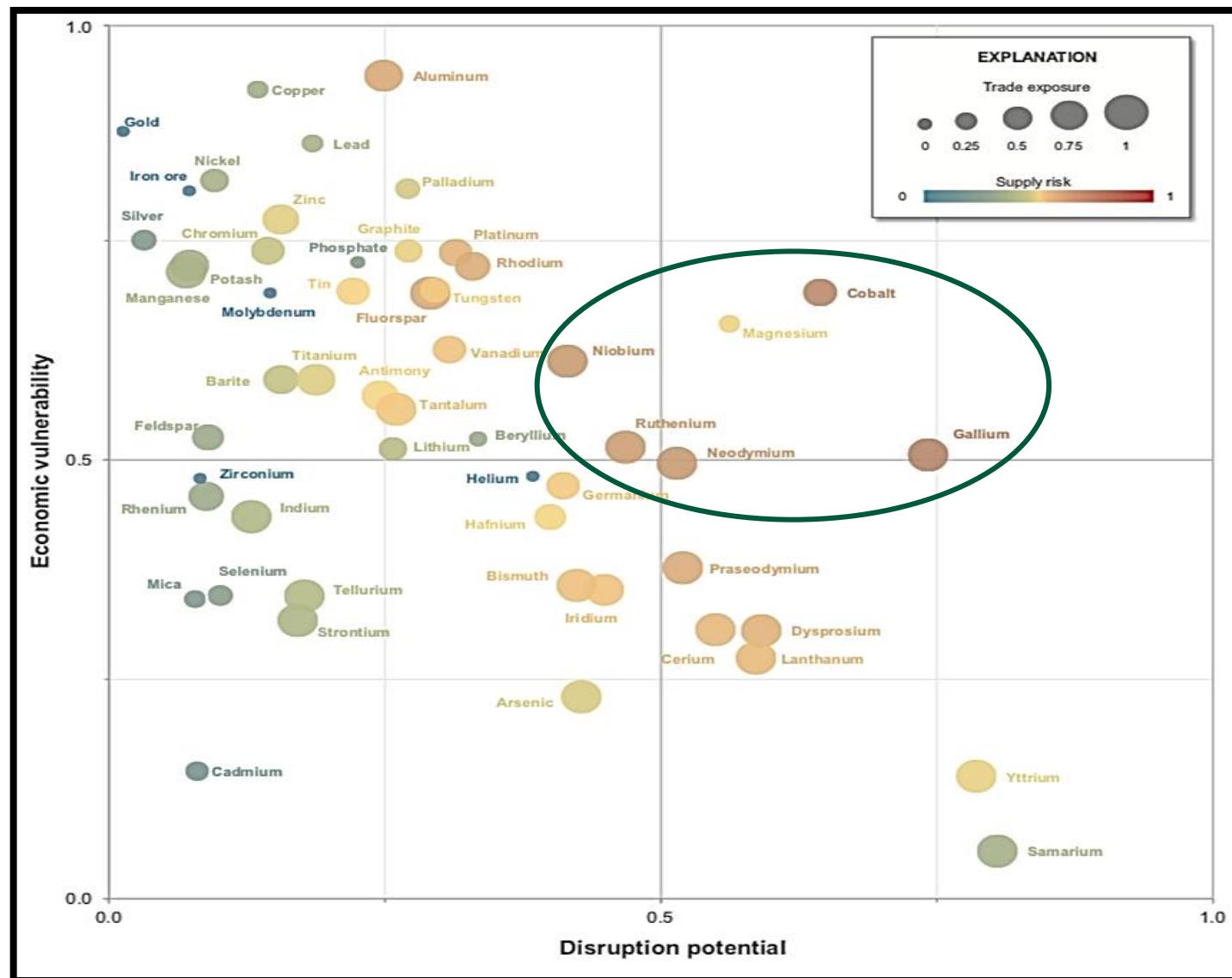
Important



Hard to get

Commodity	2018 Recency-weighted mean	Leading producing countries	
		Names and process stages	
Gallium	0.67	China	
Niobium	0.66	Brazil	
Cobalt	0.65	DRC (mining), China (refining)	
Neodymium	0.65	China (mining and refining)	
Ruthenium	0.63	South Africa	
Rhodium	0.62	South Africa	
Dysprosium	0.61	China (mining and refining)	
Aluminum	0.60	China (alumina and aluminum); Australia (bauxite)	
Fluorspar	0.60	China	
Platinum	0.60	South Africa	
Iridium	0.59	South Africa	
Praseodymium	0.58	China (mining and refining)	
Cerium	0.56	China (mining and refining)	
Lanthanum	0.56	China (mining and refining)	
Bismuth	0.55	China	
Yttrium	0.54	China (mining and refining)	
Antimony	0.53	China	
Tantalum	0.53	DRC	
Hafnium	0.51	France	
Tungsten	0.51	China	
Vanadium	0.51	China	
Tin	0.50	China (mining and smelting)	
Magnesium	0.49	China	
Germanium	0.49	China	
Palladium	0.48	Russia	
Titanium	0.48	Australia (mineral concentrate), China (sponge)	
Zinc	0.48	China (mining and smelting)	
Graphite	0.47	China	
Chromium	0.47	South Africa	
Arsenic	0.45	China	
Barite	0.44	China	
Indium	0.41	China	
Samarium	0.40	China (mining and refining)	
Manganese	0.40	South Africa	
Lithium	0.40	Australia (mining), China (refining)	
Tellurium	0.40	China	
Lead	0.39	China (mining and refining)	
Potash	0.38	Canada	
Strontium	0.36	China	
Rhenium	0.36	Chile	
Nickel	0.36	Indonesia (mining), China (refining)	
Copper	0.34	China (mining), China (smelting and refining)	
Beryllium	0.33	United States	
Feldspar	0.32	Turkey	
Phosphate	0.25	China	
Silver	0.25	Mexico	
Mica	0.22	China	
Selenium	0.23	Japan	
Cadmium	0.11	China	
Zirconium	0.09	Australia	
Molybdenum	0.07	China	
Gold	0.00	China	
Helium	0.00	United States	
Iron ore	0.00	Australia	

# A look at one perspective: USGS



# Different Perspectives + Different Timing = Different Lists

Mineral	US 2018	US 2022	EU 2023	Japan 2023	Strategic Defense
<b>Current Production in Alaska</b>					
Zinc		✓		✓	
Gold					
Silver					
Lead					

Mineral	US 2018 (35)	US 2022 (50)	EU 2023 (34)	Japan 2023 (35)	Strategic Defense (12)
<b>Historical Production in Alaska</b>					
Antimony	✓	✓	✓	✓	✓
Tin	✓	✓		✓	
Tungsten	✓	✓	✓	✓	✓
Chromium	✓	✓		✓	
Platinum		✓			
Palladium		✓			
Platinum Group Metals	✓		✓	✓	
Uranium	✓				
Mercury (not on current lists)					

# Different Perspectives – Different Lists

Mineral	US 2018 (35)	US 2022 (50)	EU 2023 (34)	Japan 2023 (35)	Strategic Defense (12)
Confirmed Resources in Alaska					
<b>Rare Earth Elements (REE)</b>	✓		✓	✓	✓
Cerium		✓		✓	
Neodymium		✓		✓	
Praseodymium		✓		✓	
Dysprosium		✓		✓	
Erbium		✓		✓	
Europium		✓		✓	
Gadolinium		✓		✓	
Holmium		✓		✓	
Lanthanum		✓		✓	
Lutetium		✓		✓	
Samarium		✓		✓	
Terbium		✓		✓	
Thulium		✓		✓	
Ytterbium		✓		✓	
Yttrium		✓		✓	✓
Copper			✓*		
Molybdenum	✓	✓		✓	
Cobalt	✓	✓	✓	✓	
Nickel		✓	✓*	✓	
Graphite (Natural)	✓	✓	✓	✓	✓
Lithium	✓	✓	✓	✓	

Mineral	US 2018 (35)	US 2022 (50)	EU 2023 (34)	Japan 2023 (35)	Strategic Defense (12)
Speculative Potential in Alaska					
Aluminum/Bauxite	✓	✓	✓	✓	
Arsenic	✓	✓	✓	✓	✓
Barite	✓	✓	✓	✓	
Beryllium	✓	✓	✓	✓	
Bismuth	✓	✓	✓	✓	✓
<b>Boron/Borate</b>				✓	✓
Cesium	✓	✓		✓	
Coking Coal				✓	
Feldspar				✓	
Fluorspar	✓	✓	✓	✓	
Gallium	✓	✓	✓	✓	✓
<b>Germanium****</b>	✓	✓	✓	✓	✓
Hafnium	✓	✓	✓	✓	
<b>Helium</b>	✓		✓	✓	
Indium	✓	✓		✓	✓
Iridium			✓		
Magnesium	✓	✓	✓	✓	
Manganese	✓	✓	✓	✓	
Niobium	✓	✓	✓	✓	
<b>Phosphate Rock</b>				✓	
<b>Phosphorus</b>				✓	✓
Potash	✓				
Rhenium	✓			✓	
Rhodium			✓		
Rubidium	✓	✓		✓	
Ruthenium			✓		
Scandium	✓	✓	✓	✓	✓
<b>Silicon Metal</b>				✓	
Strontium	✓		✓	✓	
Tantalum	✓	✓	✓	✓	✓
Tellurium	✓	✓			
Titanium	✓	✓	✓	✓	
Vanadium	✓	✓	✓	✓	
Zirconium	✓	✓		✓	

# Why create lists?

- Method for prioritization of R&D research spend:
- Diversify production: *Increase primary supply*
  - Reduce mining & milling private and external cost
  - Increase mill/refinery recovery efficiency
- Develop substitutes: *Reduce demand*
  - Improve manufacturing processes
  - Use less to achieve same properties
  - Substitute metals
  - Substitute technology
- Promote circular economies: *Enhance End of Life Recycling*

# Why create lists?

- Primary CM policy: R&D funding allocation (see previous slide)
- However, other policy includes:
- Permitting & Facilitating IBA/FPI Consent
- Stockpiles, Take/Pay contracts, Grants, Subsidies, etc
- Identify workforce needs
- Trade policy
- Information

# What are jurisdictions trying to achieve?

- Supply chain disruptions can impact manufacturing activity
  - For strategic minerals – national defense implications
  - For critical minerals – impacts to economy via manufacturing disruption
- Other goals (eg decarbonization) require deployment of significant manufactured capital
  - High external cost of delayed deployment

# Alaska's Investment Landscape



# Thank you

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