ALL THAT GLITTERS IS NOT (JUST) GOLD – CRITICAL MINERALS IN NEVADA

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Hello and thanks to NMEC for inviting me to speak today and to all of you for joining me during this talk titled “All that Glitters is not (just) Gold – Critical Minerals in Nevada.

PRESENTATION OUTLINE

- Definition of a critical mineral
- 2018 Federal Register list and occurrences/deposits in Nevada
- Historic mining districts with critical minerals occurrences/deposits
- Quantifying/qualifying foreign reliance
- Data sources review
- Overview of critical minerals that occur in Nevada on a global scale
- Activity for critical minerals in Nevada (private, state, and government)
- Data resources

As for a general presentation outline, we will review the definition of critical minerals, critical minerals in Nevada, critical minerals on the global scale, and critical mineral activity in Nevada. We will conclude with a quick review of some online data resources.

CRITICAL MINERAL DEFINITION

A "critical mineral," as defined by the E.O. 13817, is a mineral

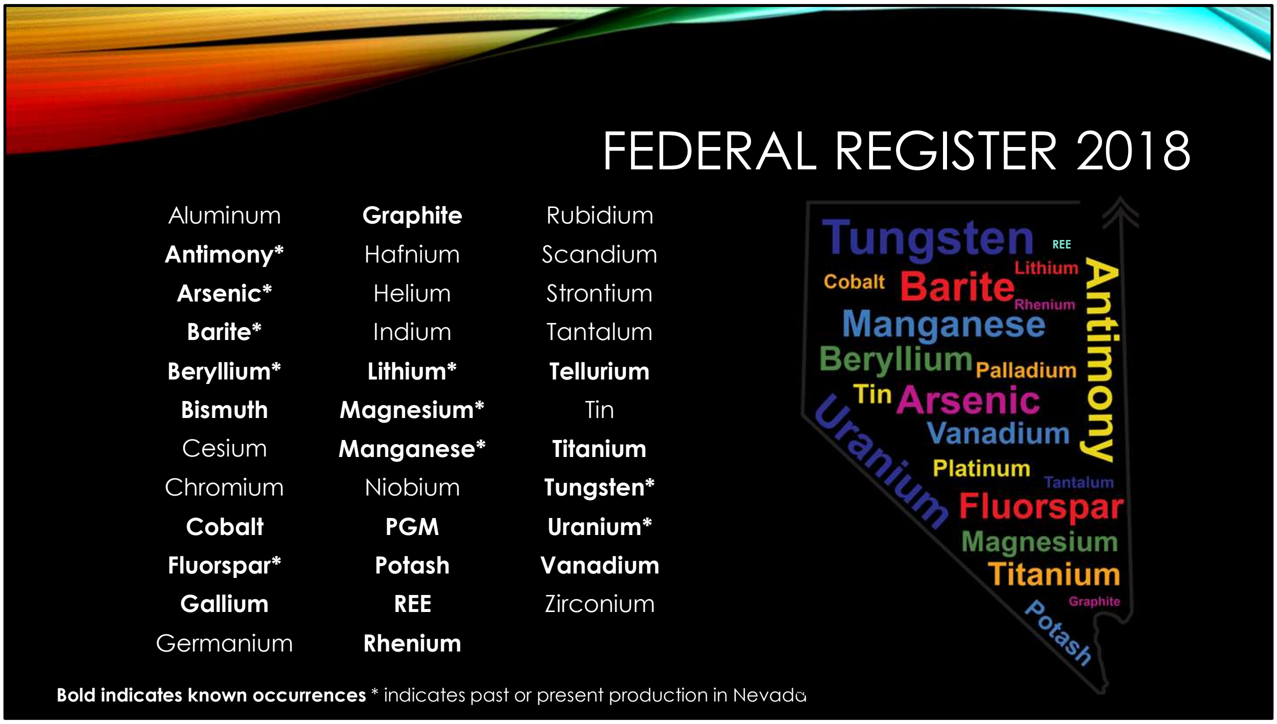
1. identified to be a nonfuel mineral or mineral material essential to the economic and national security of the United States
2. from a supply chain that is vulnerable to disruption
3. that serves an essential function in the manufacturing of a product, the absence of which would have substantial consequences for the U.S. economy or national security.

What is the definition of a critical mineral? A critical mineral is a mineral that has been

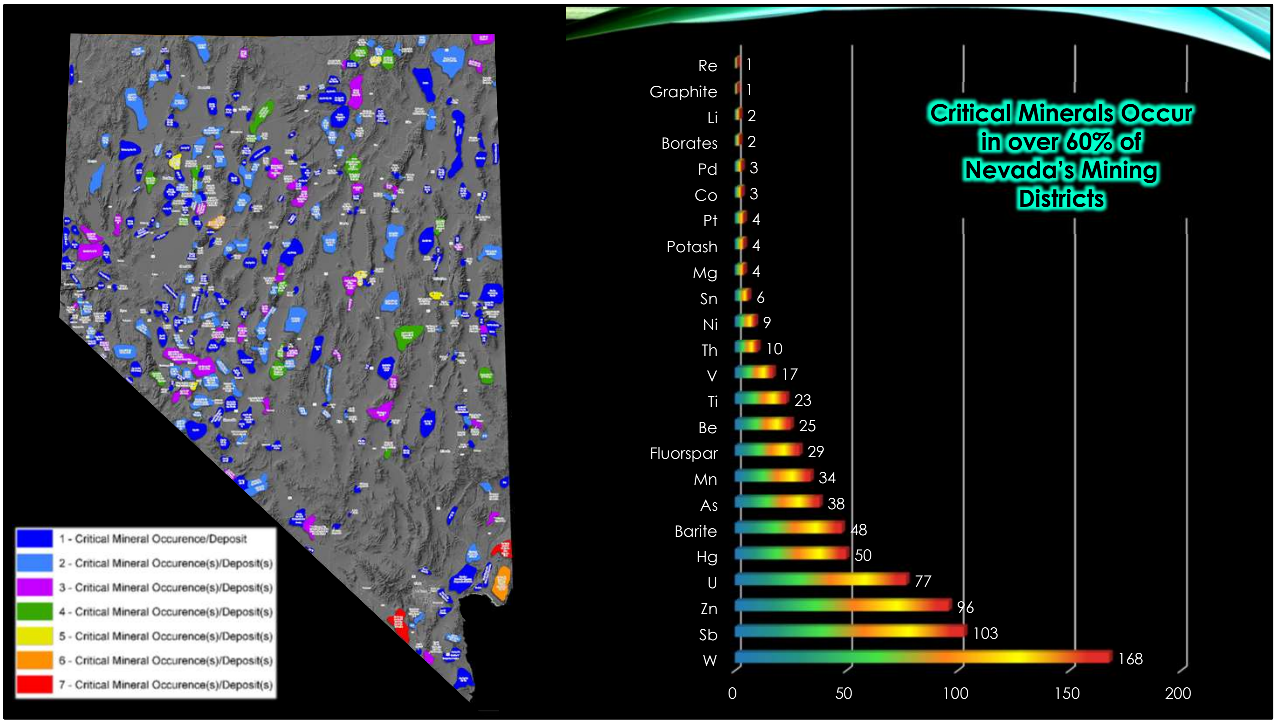
One, identified to be a nonfuel mineral or mineral material essential to the economic and national security of the United States

Two, from a supply chain that is vulnerable to disruption

And Three, that serves an essential function in the manufacturing of a product, the absence of which would have substantial consequences for the U.S. economy or national security.

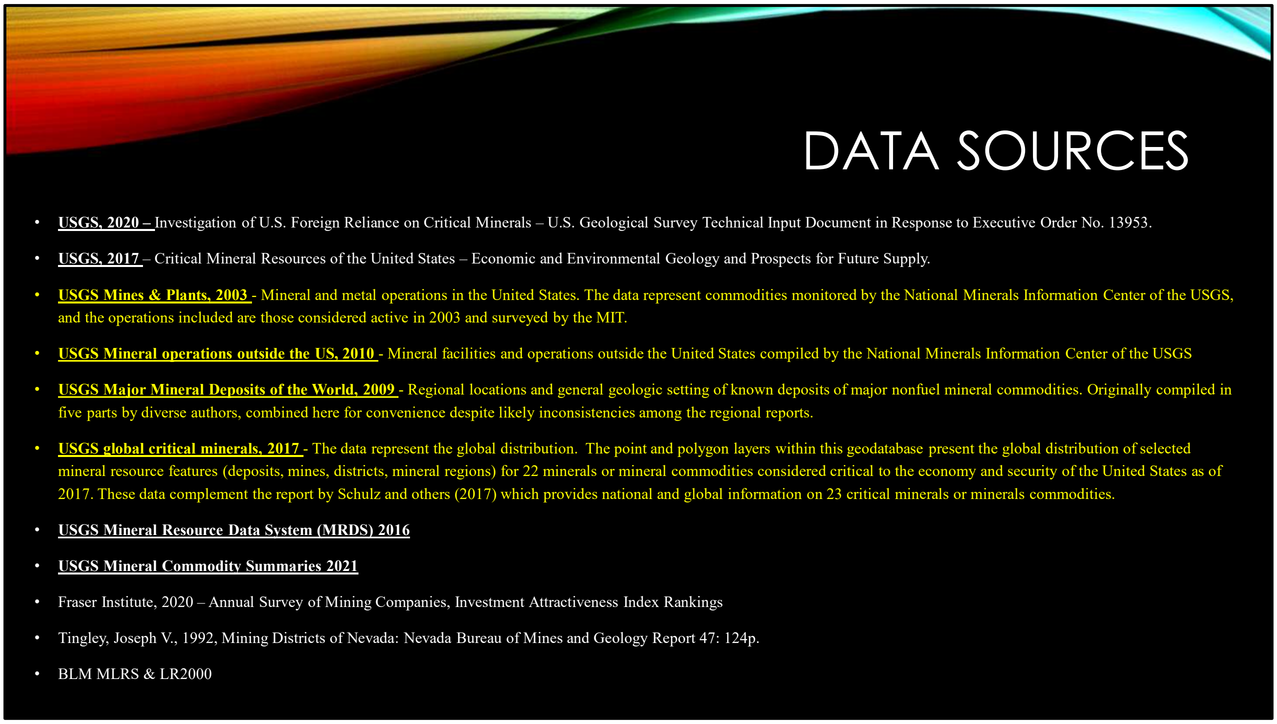


On May 18, 2018, the final list of critical minerals was published in the federal register. Of the 35 critical minerals listed, Nevada contains known occurrences or deposits of 21 of the 35 minerals. Occurrences are bold, and past production is signified with an Asterisk.

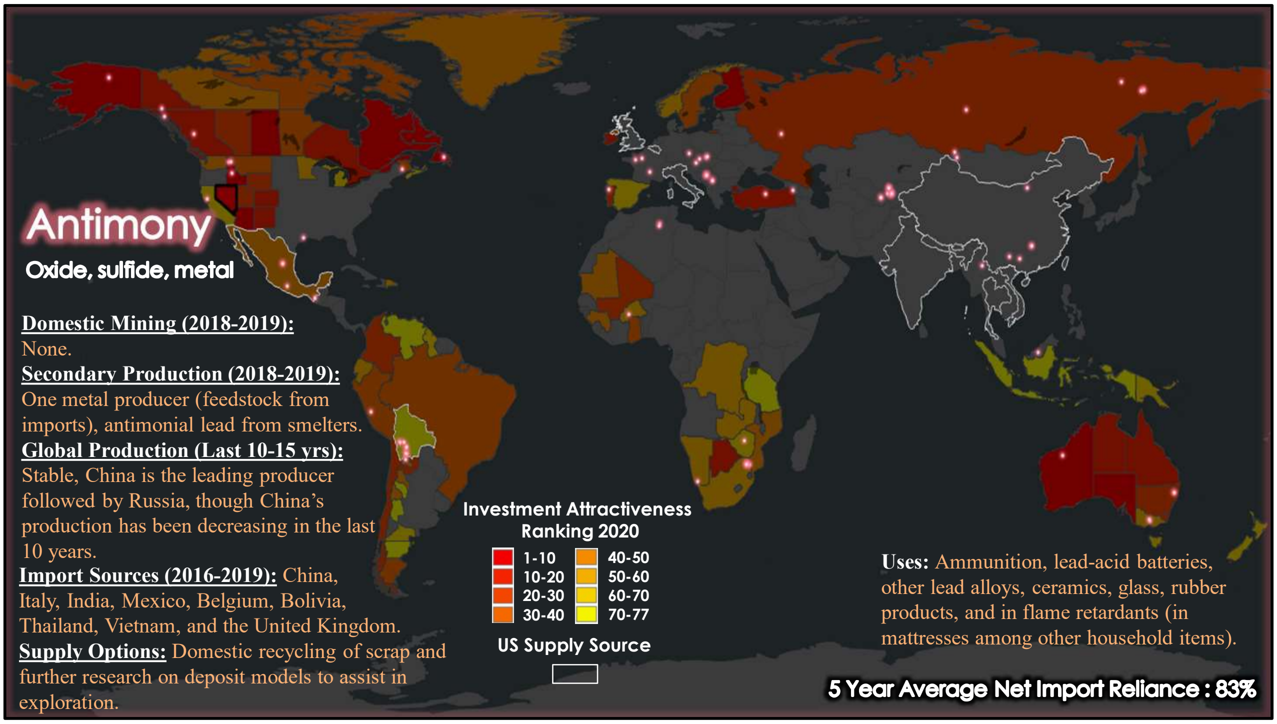


Critical minerals occur in more than 60% of Nevada's Historic Mining districts. Some more commonly than others, and several historic mining districts have more than one documented critical mineral occurrence or deposit.

Minerals that are lucky enough to land themselves on the list of critical minerals must each be scrutinized independently of one another. There are many questions that need to be addressed such as: What is the economic vulnerability of the individual mineral? How geographically concentrated is the source of each mineral? What is the disruption potential? What is the foreign ownership of the mineral assets and operations, including processing facilities? And so forth. Each commodity and form of that commodity utilized must be evaluated in detail, and where supply chains are convoluted, this may be a difficult task. Also, without a functioning crystal ball it is hard to see what technologies may emerge in the future which could impact supply and demand. Hence the reason for an ever-evolving list of critical minerals.



I would like to touch on data sources right now instead of at the end. Starting with the next slide, we will be viewing a series of maps reviewing some pertinent information for each of the critical minerals that have known occurrences or deposits in Nevada. The data for the following series of maps were obtained from the USGS and the Fraser Institute's Annual Survey of Mining Companies. While some of the USGS data is dated, these datasets are the only global representations of commodities such as Arsenic, Bismuth, Fluorspar, Magnesium, Potash, and Tungsten which were not addressed in the 2017 USGS report on critical mineral resources of the US, therefore they were not included in the 2017 critical global minerals dataset. In all maps, excluding the six commodities listed previously, all four layers shown here in yellow have been utilized. Keep the vintage of the data in mind if something you know to exist is missing. The USGS is currently working on updating these data sets and anticipates a big data publishing year in 2022.



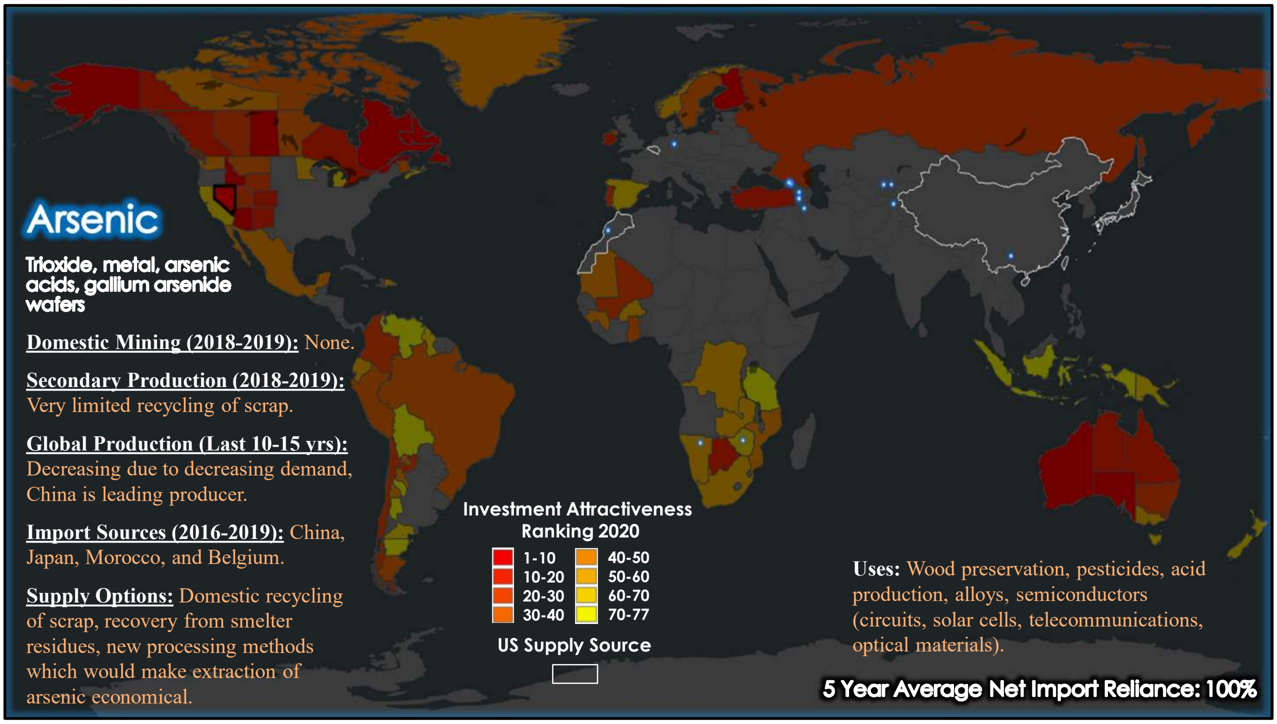
Each of the maps we will review will look like this. The glowing dots on each map represent US mines and plants, mineral operations outside the US, major mineral deposits of the world, and global critical minerals deposits, mines, districts and mineral regions. Countries, states, and provinces are color coded according to their investment attractiveness ranking in the 2020 Fraser institute annual survey of mining companies. Red being the highest-ranking jurisdictions and yellow being the lowest. Those regions lacking color either did not respond or did not provide enough data to be evaluated in the survey. The countries that are import sources for the US for the highlighted commodity are outlined in white.

Each slide supplies a list of commodity forms considered critical, a summary of domestic mining and secondary production from 2018-2019, global production during the last 10-15 years, import sources from 2016-2019, alternative supply options, major uses as presented by the USGS in their 2017 and 2020 publications. Also shown in the bottom right-hand corner of each slide is the 5-year average of our net import reliance calculated from figures presented in the USGS Mineral Commodity Summaries 2021. Import reliance refers to the reliance on foreign sources for raw and processed mineral materials.

I am not going linger on any of these slides for very long. I am only going to present the highlights. This presentation will be made available on our "recent presentations" page on the Nevada Division of Minerals' website and in the critical minerals section on our open data site.

Rolling in alphabetical order we will start with antimony, for which some mining has taken place in the last 10 years, but no mining was reported in 2020. There is one metal producer here in the US who is totally reliant on imported feedstock. The US 5-year average net import reliance is for antimony is 83%. We import from several regions of the world which are listed in this screen. China is the leading global producer of antimony followed by Russia. Some alternative supply options for antimony include recycling and further research on deposit models to further assist in exploration.

USGS 2020 Paragraph:
Antimony metal is used in ammunition and lead-acid batteries as well as other lead alloys. Antimony is used in nonmetallic form in ceramics, glass, and rubber products and in flame retardants.
Although domestic resources of antimony ore have been commercially mined in the past 10 years, no mine production was reported in 2020. Some primary and secondary smelter production took place. Refinery production occurs with imported feedstock of concentrates and oxides, largely from China, which is also the world's leading concentrate producer. However, Chinese production has decreased over the past 10 years. Russia and Tajikistan, now the second- and third-ranked producers, respectively, have increased antimony production.

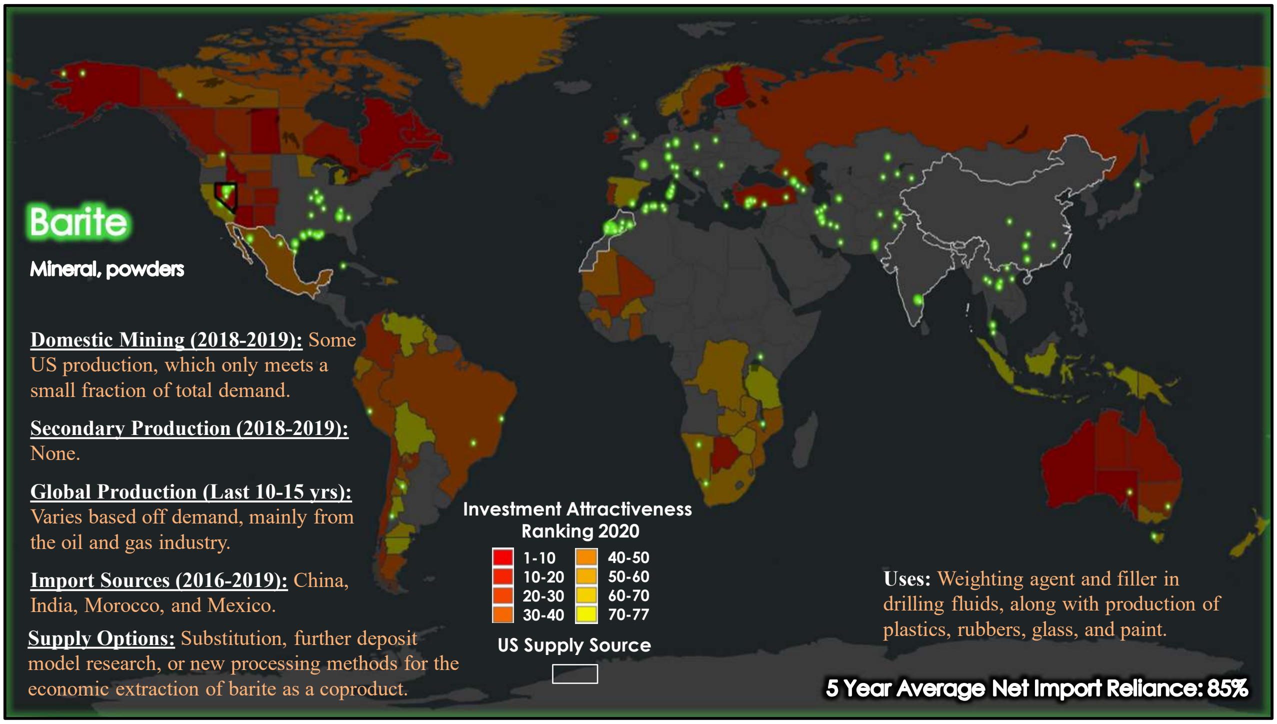


Arsenic. Recovery of arsenic in the US is generally not economical, so it is generally discarded resulting in a 100% import reliance. China, Japan, Morocco, and Belgium are the main source of US imports. There is very limited recycling of scrap. In metal form, arsenic is used in alloys and semiconductors for electronics, integrated circuits, solar cells, telecommunications, and specialty optical materials, of which China is the leading producer. Some supply options include more recycling of scrap, recovery of arsenic from smelter residues and the development of new processing methods which would make domestic extraction economical.

USGS 2020 Paragraph:

The largest application for arsenic is for wood preservation and pesticides, where arsenic trioxide is used to produce arsenic acids that are then formulated into chromated copper arsenide. In metal form, arsenic is used in alloys and in semiconductors, such as gallium arsenide, indium gallium arsenide, and germanium arsenide selenide which are used in electronics for integrated circuits, solar cells, telecommunications, and specialty optical materials.

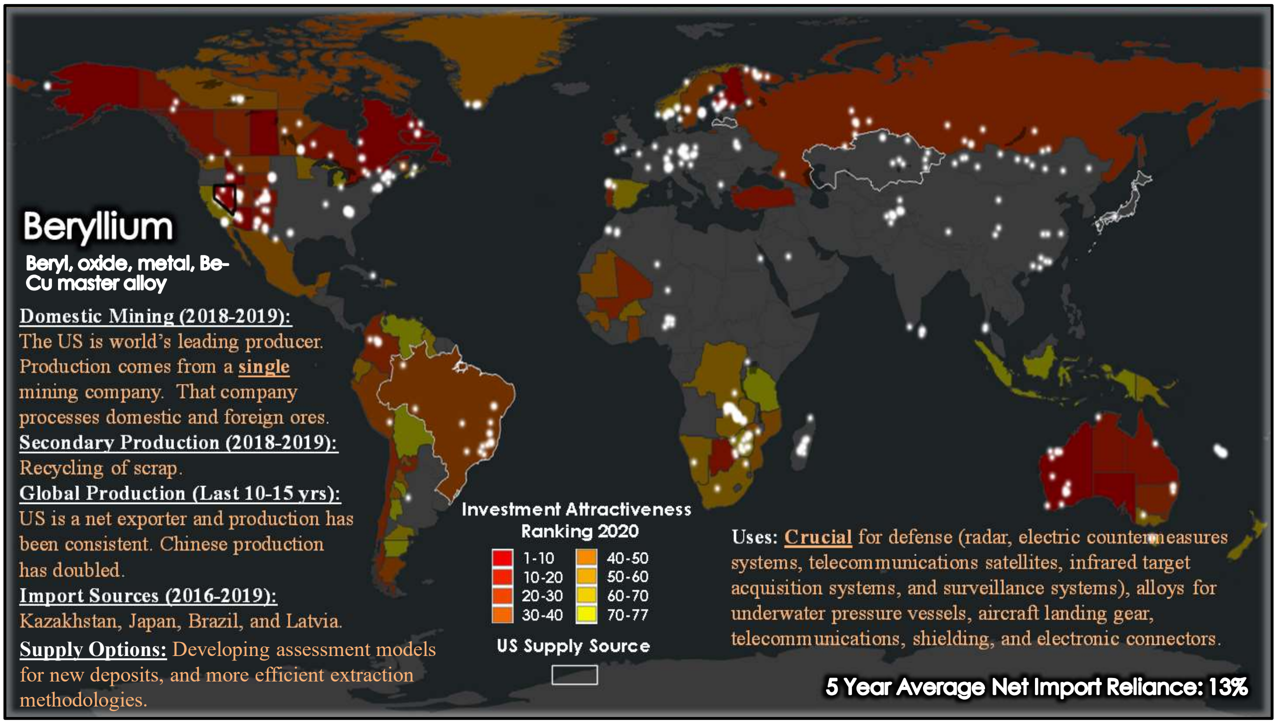
Arsenic is very common in the Earth's crust and could be produced at many base and precious metal mines, based on arsenic concentration in the ore. However, it is not *profitable; therefore, the arsenic is usually discarded. China produces more than one-half of the world's arsenic trioxide, and although no data were available on China's production of arsenic metal, it is the source of more than 90 percent of imports to the United States. The United States has no domestic production and has not produced any arsenic for years except for limited recycling of scrap generated during gallium arsenide manufacturing. However, arsenic is potentially recoverable from domestic smelter residues because it is found in domestic ores, albeit in low concentrations.*



Barite production fluctuates globally mainly due to fluctuations in…you guessed it, the oil and gas industry. There is limited domestic production of barite, which only meets a small fraction of total US demand. Net import reliance is 85%. Substitution, deposit model research, and new processing methods are options put forth to reduce foreign reliance.

USGS 2020 Paragraph

Barite, or barium sulfate, is an insoluble mineral that is used predominantly as a weighting agent and filler material in drilling fluids in the oil and gas industry. Although alternative materials are available, barite is the material of choice for that application. Barite also is used in the production of plastics, rubbers, glass, and paint, as well as a in a few niche applications where substitution may be more challenging. Reserves data are not available for the United States, but barite is produced at a few mines. Production quantities are sufficient to meet only a small fraction of domestic demand, and most of demand is met by imports. About a dozen countries mine barite, although China and India, combined, produce about one-half of the world's barite. More than one-half of imports to the United States are from China, with the rest coming mostly from India, Morocco, and Mexico.

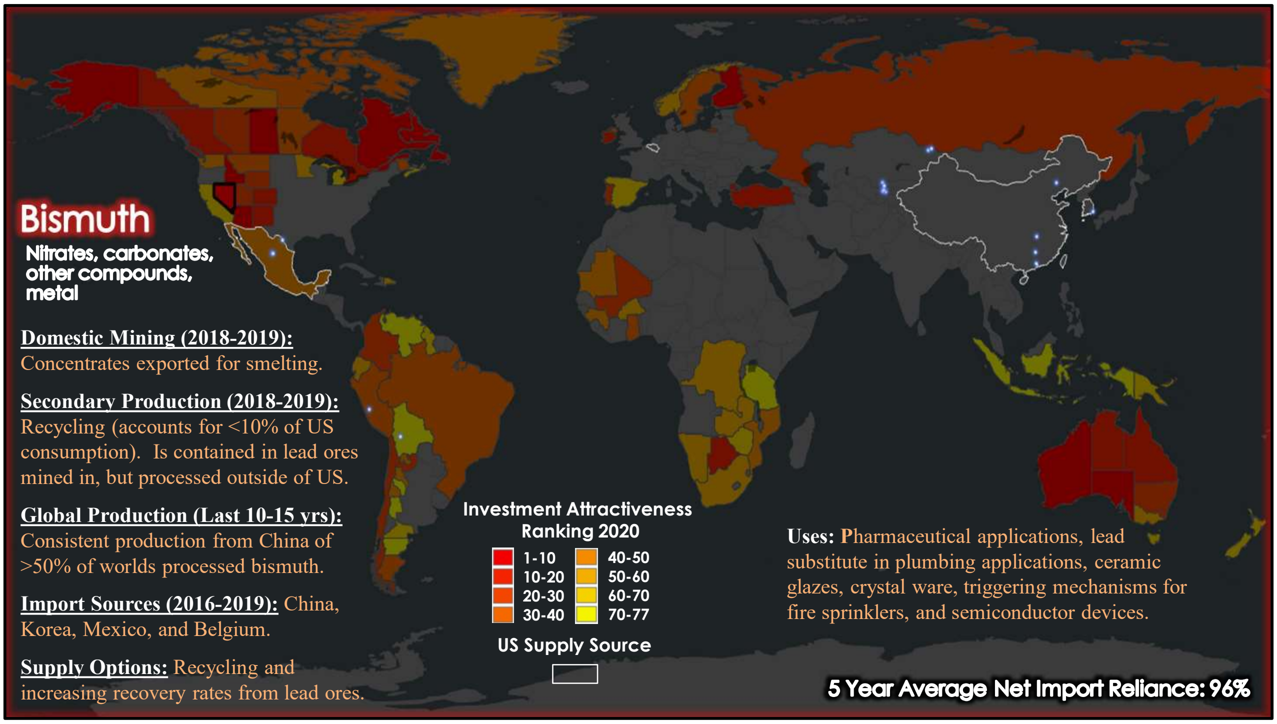


The US is the leading producer of beryllium, but production of this crucial commodity is from a single mining company. Net import reliance is calculated by taking imports – exports + adjustments for government and industry stock changes which leaves the US 13% net-import reliant. Minor domestic recycling is taking place. During the last 10 to 15 years, US production has remained consistent, where Chinese production has doubled. Options for securing beryllium supply include developing assessment models for new deposits and more efficient extraction methodologies.

USGS 2020 Paragraph

Beryllium metal is crucial for defense applications such as radar, electronic countermeasures systems, telecommunications satellites, infrared target acquisition systems, and surveillance systems. It is also alloyed with copper for commercial applications such as underwater pressure vessels, aircraft landing gear, telecommunications, shielding, and electronic connectors. Although beryllium is toxic, limiting how it can be handled, it has properties that make it highly desirable; therefore, substitution is very challenging in the applications where it is used, especially for defense.

The United States dominates global beryllium mine and metal production, with only a *handful of other countries producing beryllium. China is the world's second ranked producer of beryllium but produces less than a one-third the quantity produced by the United States. All U.S. primary production of beryllium is from a single company, which received Federal Government funding to build a primary beryllium facility. Beryllium is also held in the National Defense Stockpile (NDS) for national emergency purposes. Some recycling of beryllium is possible and currently practiced, although the quantity is not reported.*

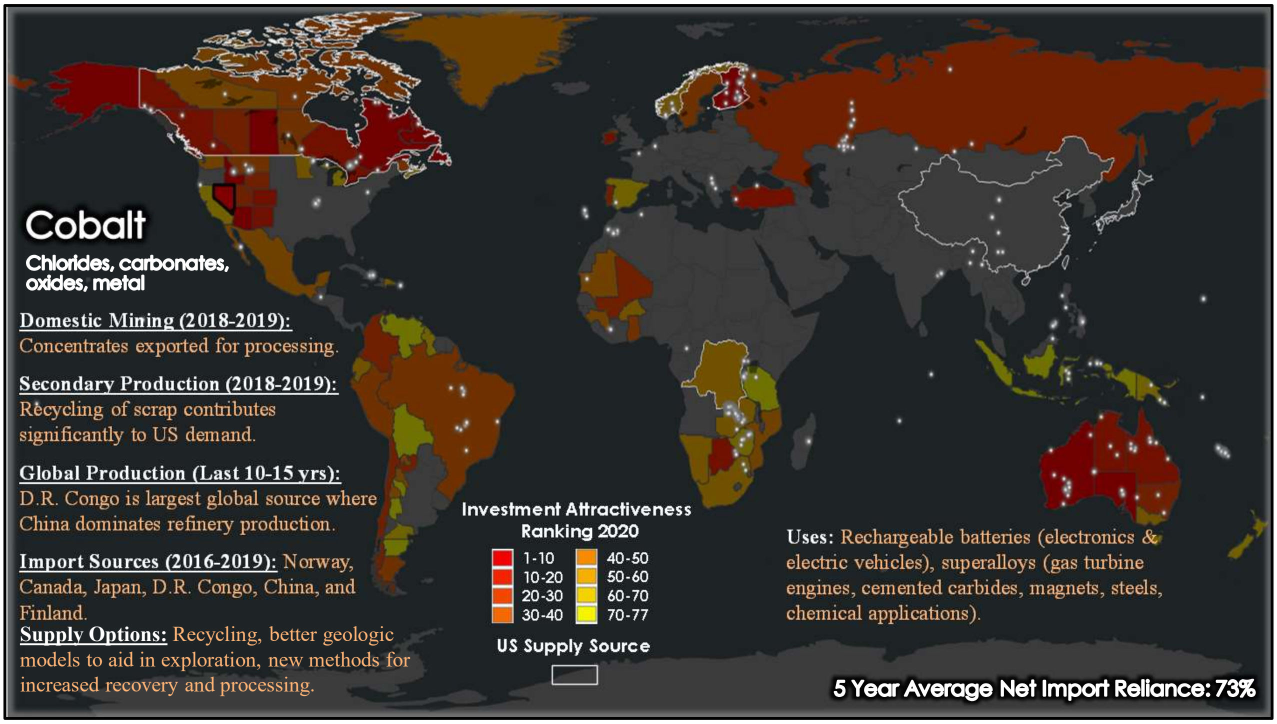


Onto bismuth. Bismuth is contained in lead ores mined domestically but are processed outside of the US. Recycling accounts for less than 10% of US consumption. Global production during the last 10-15 years has remained consistent with over ½ of the worlds processed bismuth coming from, yes…China. The average net import reliance for bismuth comes to 96%. The US relies on China, Korea, Mexico and Belgium for imports. More recycling and increasing the recovery rates from lead ores could help to maintain supplies.

USGS Paragraph

For many of its end uses, bismuth is combined with other metals and compounds, making it difficult to track quantitatively through the supply chain. One of the major end uses is in pharmaceutical applications, where bismuth is used to treat acid reflux, stomach ulcers, burns, and intestinal disorders. Another end use is in metal form as a nontoxic substitute for lead in pipe fittings, water meters, and other plumbing applications. Bismuth is also used in small quantities in a wide variety of applications such as ceramic glazes, crystal ware, triggering mechanisms for fire sprinklers, and some semiconductor devices.

On the supply side, domestically, bismuth is contained in and mined with lead. However, it is not recovered or processed domestically. Small amounts are recycled, specifically *bismuth-containing alloy scrap, but no recycling is possible for many of bismuth's applications such as for pharmaceuticals. As a result, the domestic supply chain is mostly reliant on imports, which are largely from China, the world's leading producer of bismuth metal and compounds. Alternative producers include Laos, the Republic of Korea, Japan, and Mexico.*



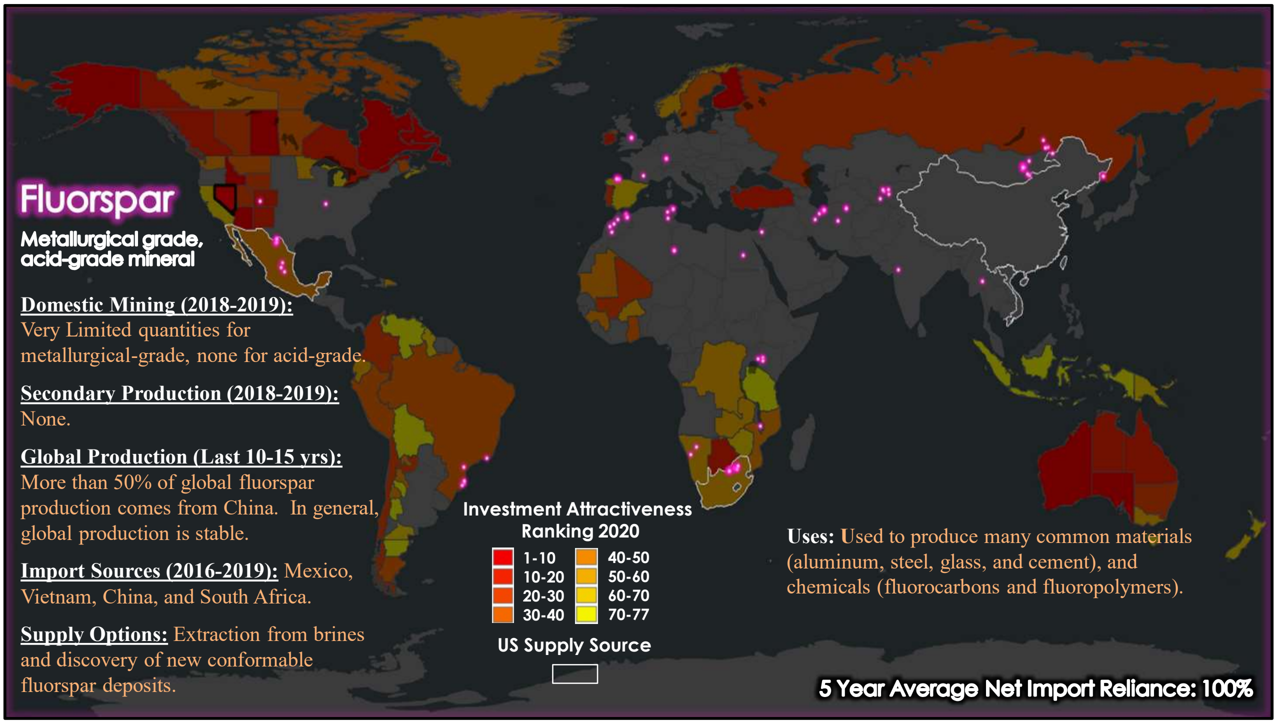
Cobalt. One active mine in Michigan, and mine tailings from Missouri produced cobalt bearing concentrates. These concentrates are exported internationally for processing elsewhere. Recycling of scrap significantly contributes to US supplies lowering the average net import reliance to 73%. The Democratic Republic of the Congo is the largest global source of cobalt, though China dominates refinery production. Imports of cobalt to the US are sourced from the Democratic Republic of the Congo, Norway, Japan, Finland, and China. Supply options include recycling, better geologic models to assist in the exploration for new deposits, and new methods which would increase recovery and processing.

USGS Paragraph

Cobalt is well known for its use in rechargeable batteries for consumer electronics and electric vehicles. The latter application now represents the leading global use. In contrast, most domestic consumption of cobalt is in superalloys for gas turbine engines, cemented carbides, magnets, specialty steels and various chemical applications. Cobalt provides specific performance advantages (for example, high strength, corrosion resistance, or cycle stability) in many of these applications, and substitutions, when possible, may increase cost.

Most mined cobalt, approximately 70 percent, is supplied by the D.R. Congo as a co-

product or byproduct of copper or nickel production. Similarly, refinery production is extremely concentrated. China is the world's leading producer of refined cobalt and imports cobalt from mining countries to meet its refinery demand. The United States is not highly dependent on China to fulfill its overall cobalt demand because domestic consumption is largely unwrought cobalt metal, and China principally exports cobalt powder and cobalt hydroxide. Only about one-tenth of cobalt imports (in all forms) to the United States come from China. Instead, the United States is reliant on a variety of other exporting countries, including Norway and Japan.

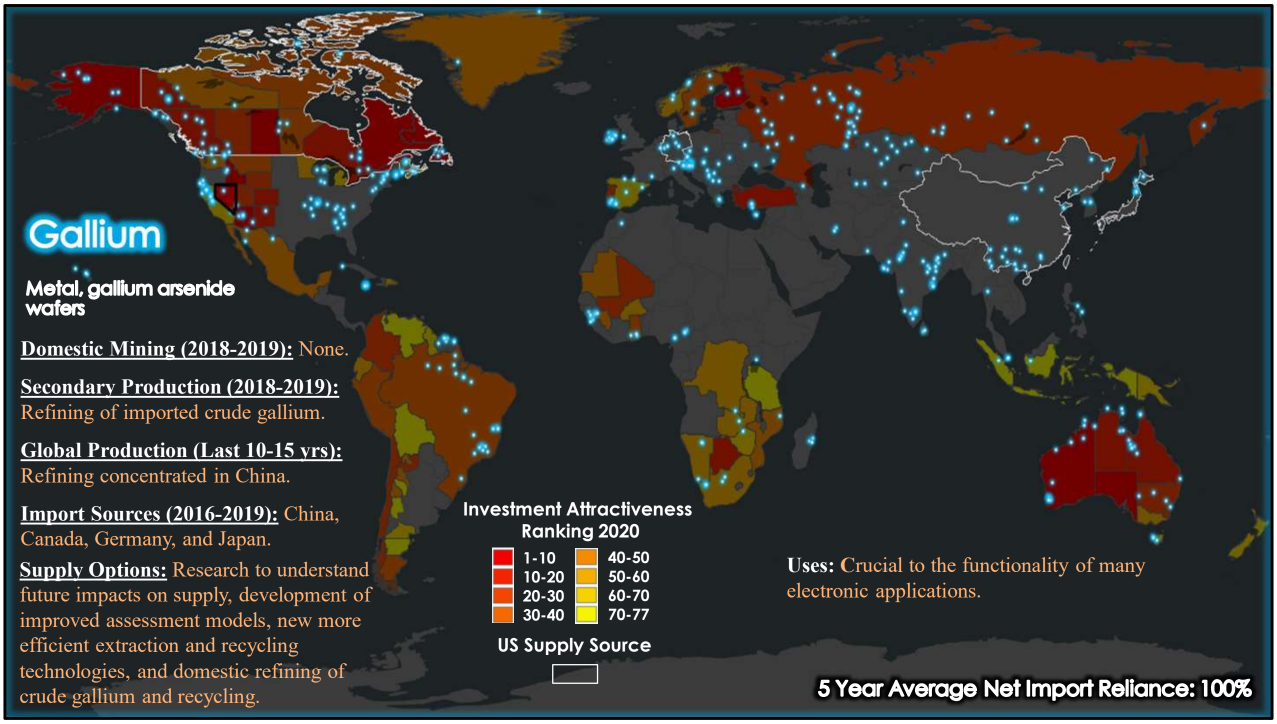


Next up, Fluorspar. Metallurgical grade fluorspar is mined domestically in limited quantities but there is no mining for acid-grade fluorspar and there is also no recycling. The US is 100% reliant on fluorspar imports, most of which come from Mexico. Vietnam, China, and South Africa are secondary import sources. Global production of fluorspar has remained stable with China producing over 50% of the global supply. Domestic supply options include possible extraction from brines and emphasis on discovering new conformable fluorspar deposits.

USGS Paragraph

Fluorspar, the mineral form of calcium fluoride, is generally subdivided into two grades that do not substitute for each other: metallurgical grade and acid grade. Fluorspar is used in the production of many other materials, including aluminum, steel, glass, and cement, as well as in precursor chemicals, fluorocarbons, and fluoropolymers. The importance of fluorspar is difficult to gage but is clearly significant because these materials are used across many industrial sectors, including construction, transportation, electronics, and healthcare. U.S. apparent consumption fluctuates from year to year with generally lower consumption in the past few years compared with that of a decade ago.

Domestic resources are large but not well quantified. Although some limited domestic *production of metallurgical-grade fluorspar takes place, no acid-grade fluorspar is produced domestically. Although China produces more than one-half of the world's fluorspar, the United States sources most of its imports from Mexico, and supply has been stable.*



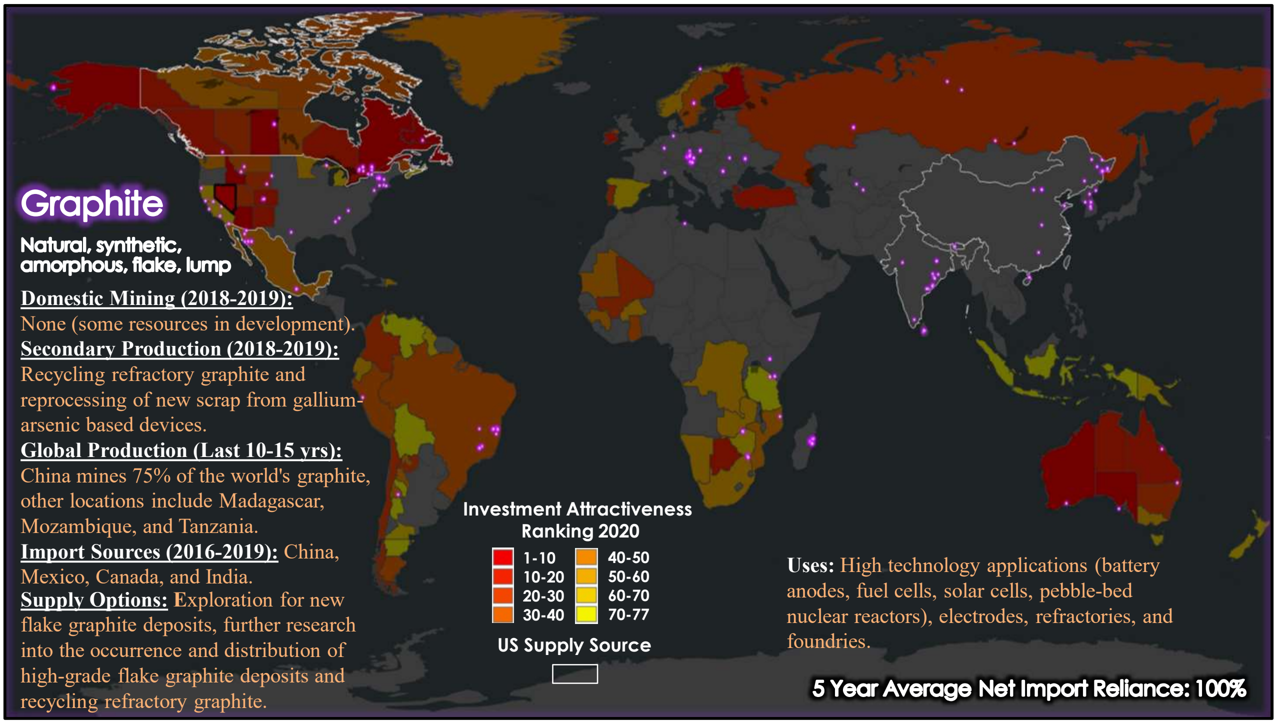
Gallium is crucial to the functionality of many electronic applications like the computer and projector being used to convey this information to you. There is no domestic mining of gallium, though we do refine imported crude gallium making the US 100% reliant on imports. China leads the globe in crude gallium, production and is the main source of US imports. Secondary sources include Canada, Japan and Germany. Options to meet consumptive demands include research to understand future impacts on supply, the development of improved assessment models, new and more efficient extraction and recycling technologies, along with more domestic refining and recycling.

USGS Paragraph

Although world production of gallium is less than 500 metric tons annually, this minor metal is crucial to the functioning of many electronic applications, including integrated circuits for satellite communications. In many applications, gallium provides high-efficiency, high-frequency, high-power, and low-noise properties that make substitution with other materials difficult.

Crude gallium is largely extracted as a byproduct of bauxite and alumina refining. It is also extracted as a byproduct of zinc. Most alumina and zinc refiners do not capture it, and crude gallium is not produced domestically. China produces almost all the world's crude gallium and is the primary source of the gallium imported by the United States.

China also is the source of most of the gallium arsenide wafers imported into the U.S. Over the past 10 years, Chinese production of crude gallium has increased. China's market share has increased to the point that alternative primary sources of gallium are increasingly limited. China also produces most of the world's refined and high-purity gallium and has been moving to increase its market share.
However, the domestic supply chain refines imported crude gallium into high-purity gallium. In addition, secondary sources include domestic production and production from countries such as Canada, Germany, and Japan.



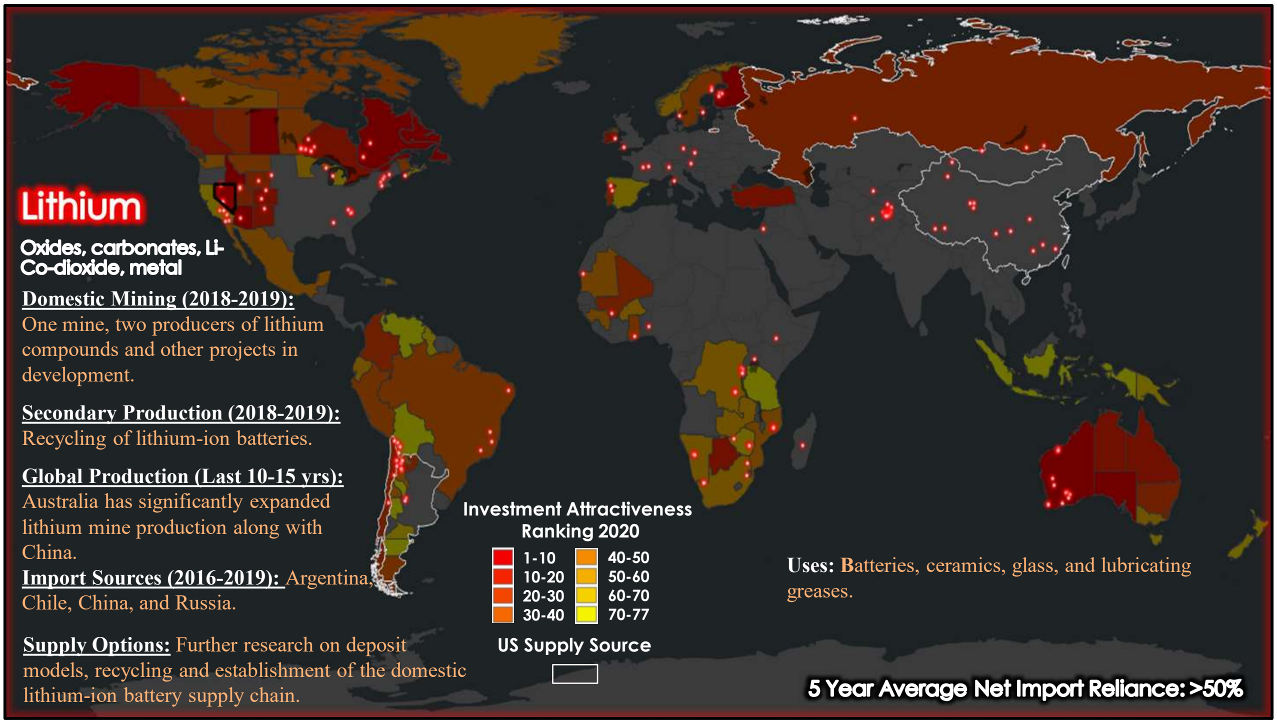
Onto graphite. While there has been no recent mining of graphite in the US, there are some resources currently in development. There is domestic recycling of refractory graphite. The US is 100% reliant on imports. China mines 75% of the world's natural graphite and has some of the world's largest resources. China, Mexico, Canada, and India are all import sources for natural graphite in the US. Options to aid in domestic supply include exploration, further research into the occurrence and distribution of high-grade flake graphite deposits, and more recycling of refractory graphite.

USGS paragraph

Graphite is increasingly becoming an essential component in high technology applications, especially energy technologies, including battery anodes, fuel cells, solar cells, and pebble-bed nuclear reactors. More traditional uses of graphite are associated with the ferrous and nonferrous metal manufacturing industries; major consuming applications include electrodes, refractories, and foundries.
Importantly, newer and more traditional applications consume very different forms of graphite. Graphite is available in natural and synthetic forms. Natural graphite can be classified into three types: amorphous, flake, and lump, which in turn can be further processed and treated to create specialty or higher-grade products (for example, spherical graphite). Examples of the specificity by application include battery anodes,

which require spherical graphite; electrodes, which require synthetic graphite, and most refractories, which require natural flake. This specificity is important when considering import reliance.

Production of natural and synthetic graphite is highly concentrated in China, one of the leading producers, exporters, and consumers of both forms. Furthermore, the country produces almost all the spherical graphite used in batteries. In terms of imports, the United States is highly dependent on graphite (all forms) from China. However, current U.S. consumption of synthetic graphite is largely satisfied by domestic production, which is robust (the United States is a major synthetic producer). In contrast, no natural graphite is produced domestically; although, several U.S. deposits are under development (including one in Alabama and one in Alaska). Consequently, for domestic uses requiring natural graphite, most imports come from China.



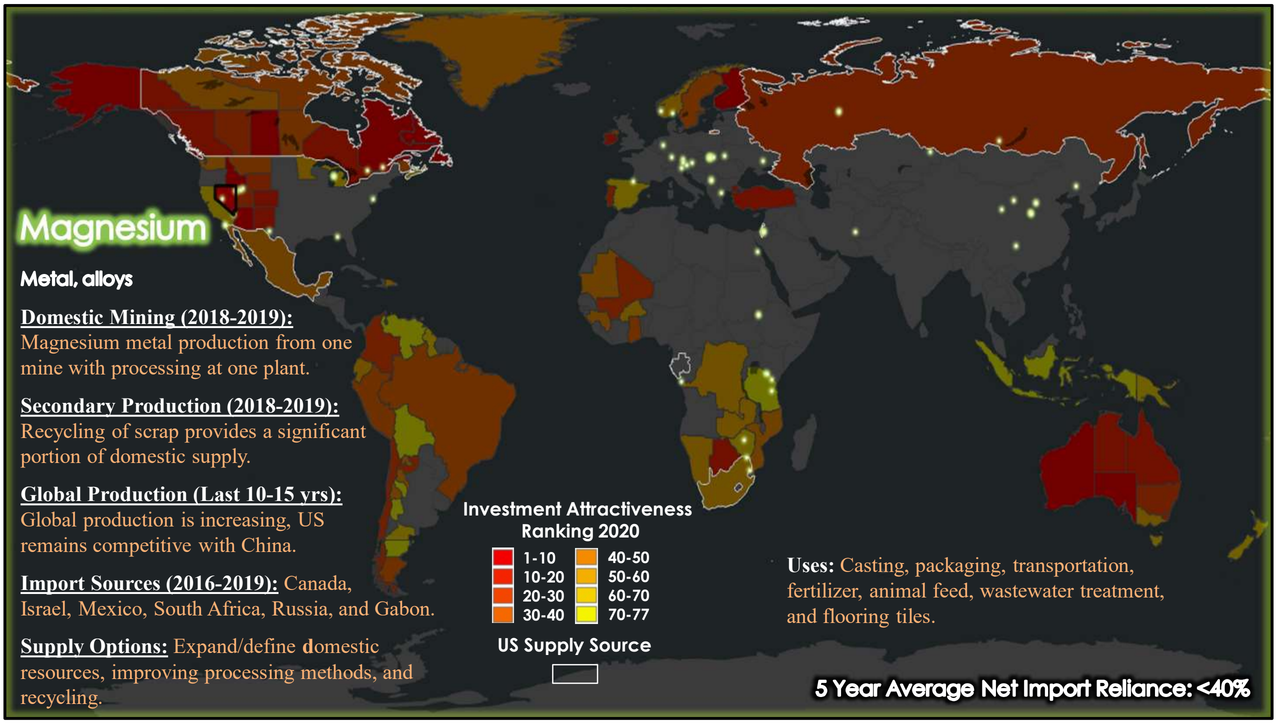
I bet nobody has heard ANYTHING about this one…Lithium. Here in the US, there is one producing mine and two producers of lithium compounds along with domestic recycling of Li-ion batteries. The US is greater than 50% net import reliant, and what is imported comes from Argentina, Chile, Russia, and Asia. Key lithium compounds used in lithium-ion batteries is concentrated outside the US, mostly concentrated in China. Supply options include further research on deposit models, recycling, and the establishment of the domestic lithium-ion battery supply chain.

USGS Paragraph

Globally, the largest market for lithium products was batteries, followed by ceramics and glass, and lubricating greases. World consumption of lithium has grown steadily over the last decade, especially in recent years as use in batteries has significantly increased.

Lithium is extracted from two sources—brine operations and hardrock ores—and then processed into a variety of compounds, including lithium carbonate, chloride, and hydroxide. The United States has one producing brine operation in Nevada and two producers of lithium compounds. The United States relies primarily on Argentina and Chile for lithium carbonate imports, and slightly on China for lithium hydroxide. The United States is actually a net exporter of lithium hydroxide. World production of

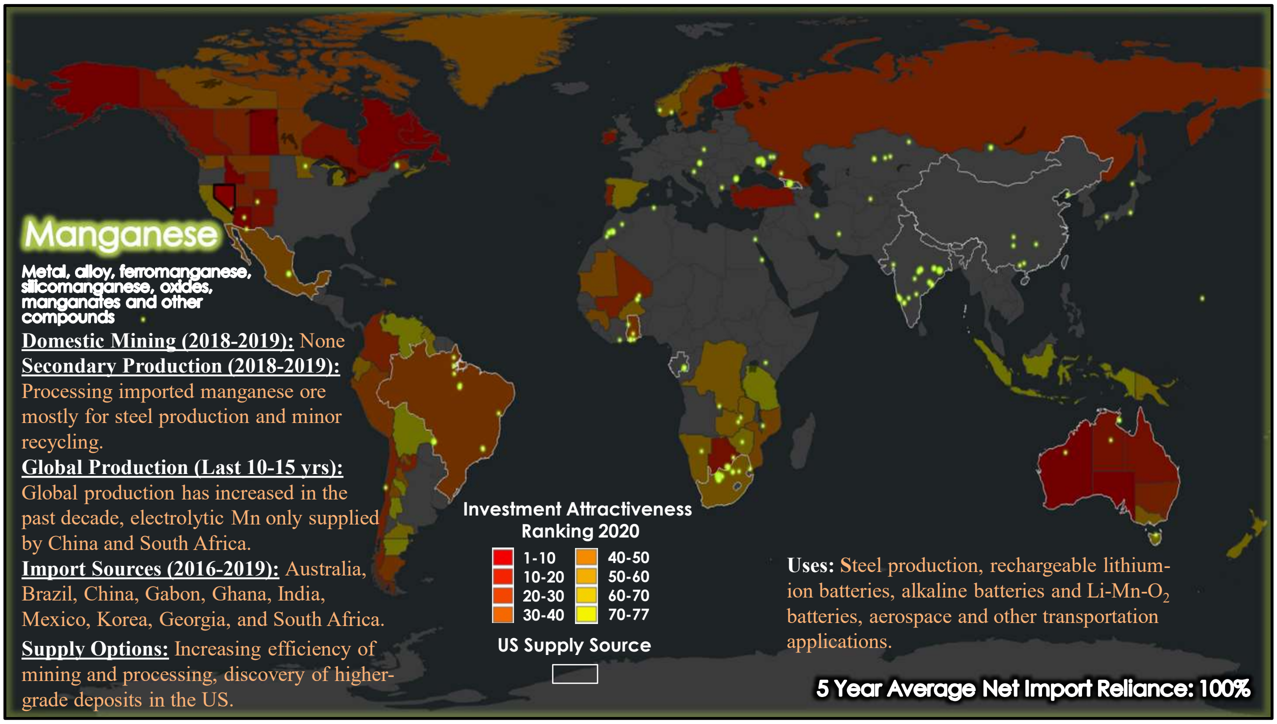
lithium has exceeded demand in recent years, and prices have fallen, leading to different operational responses. Existing producers have paused capacity expansion, whereas in some cases, new producers have shut down.
Increasingly, lithium metal and lithium-ion batteries are being recycled, and new technologies for recycling are under development.



Magnesium. Domestic production and recycling accounts for a large portion of domestic consumption bringing the US average net import reliance to less than 40%. Imported magnesium metals come from Canada, Israel, Mexico, South Africa and Gabon. In order to maintain or improve domestic supply, actions include expanding domestic resources, improving processing methods and recycling.

USGS Paragraph

Approximately one-half of magnesium metal produced is used for castings in applications where magnesium's high strength-to-weight ratio is important, such as in the automotive industry. This end-use category has grown over the past decade. Magnesium metal has poor formability, but when alloyed with aluminum, it is commonly used for packaging and transportation. Magnesium compounds have very different uses than the metal and are predominantly used in refractory, fertilizers and animal feed, wastewater treatment, flooring tiles in construction, and several chemical industries. Magnesium is the eighth most abundant element in Earth's crust, but the process to produce metal is energy intensive and technically challenging and therefore quite costly. Only a fraction of magnesium mined is turned into metal; most is used in the form of compounds. ***Domestic production of magnesium metal occurs in a single plant sourcing magnesium from brine.*** *Production from that plant plus recycling (from* *domestic and imported scrap) produce more than one-half of the magnesium metal consumed domestically. China produces more than 85 percent of the world's magnesium using a process that is known to be environmentally destructive, but inexpensive. Production at larger scale and ongoing technological improvements have made it possible for the United States to remain competitive with China.*

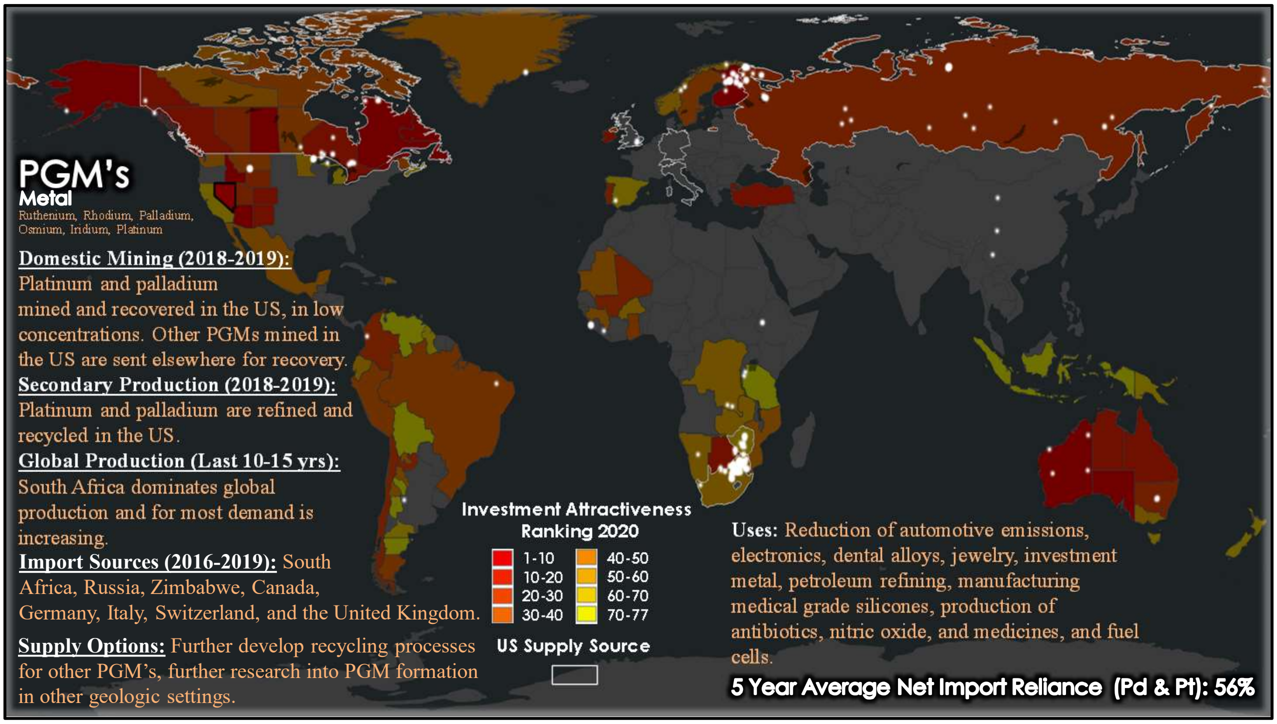


Now for manganese. Imported manganese ore is processed domestically. The US net import reliance figure for manganese is 100%. Electrolytic manganese utilized in aerospace and other transportation applications is only supplied by China and South Africa. Manganese ore is imported from several countries, which are all listed on the screen. Options for boosting domestic supply include increasing processing and mining efficiency, along with the obvious discovery of local higher-grade deposits.

USGS Paragraph

Almost all manganese is used in iron and steel production, consumed either in the form of ore or as a ferroalloy. In steelmaking, manganese is indispensable. Steel, the most produced metal in terms of annual tonnage, is used across every economic sector from construction to transportation to machinery. In nonsteel applications, manganese is used in some rechargeable lithium-ion batteries, alkaline batteries, and lithium-manganese-dioxide nonrechargeable batteries. Also, electrolytic manganese metal, which is manganese metal with 99 percent or greater purity, is a special form of manganese used in nonferrous alloys such as aluminum alloys used for aerospace and other transportation applications.

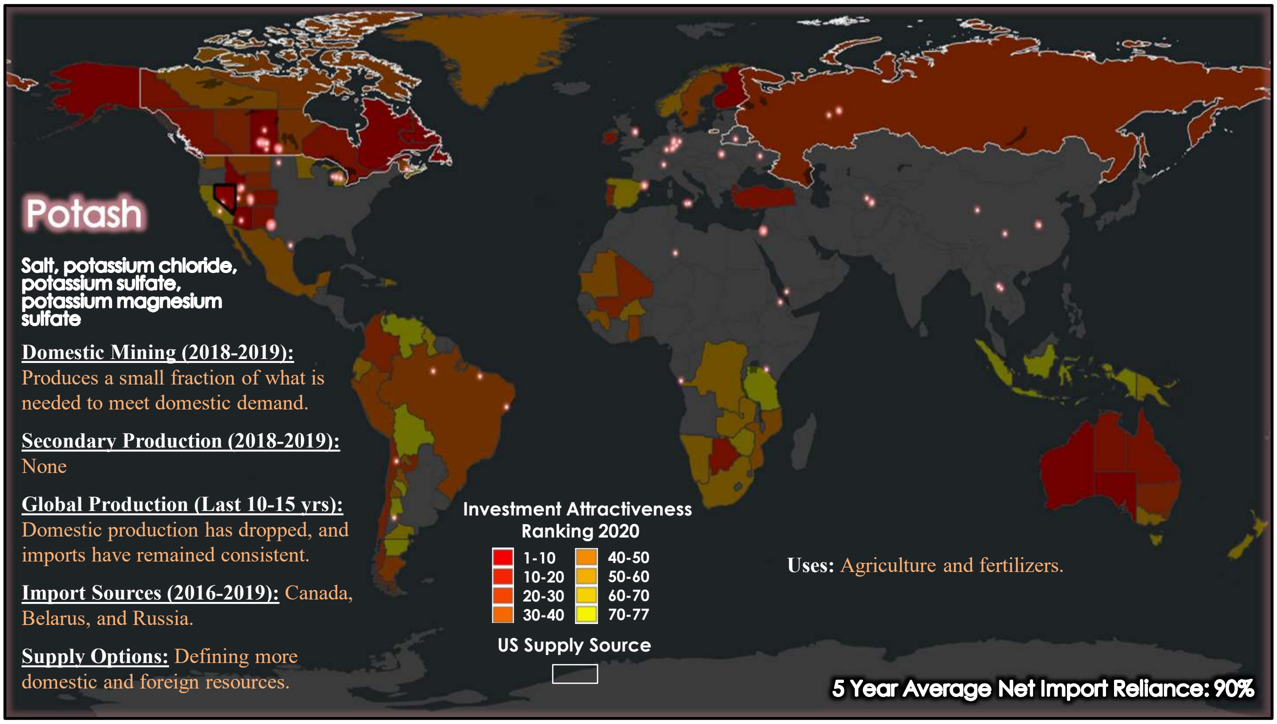
Manganese ore is not mined domestically. The United States imports all manganese that *is consumed by the domestic supply chain, whether to produce steel or to produce various forms of manganese such as ferromanganese, silicomanganese, and manganese chemical compounds. In terms of ore, import source options are varied, with Australia, Brazil, China, Gabon, Ghana, India, and South Africa among the many producers of manganese ore. In terms of electrolytic manganese metal, imports options are very limited with China dominating global production, and only South Africa as a known alternative supplier. The NDS holds manganese ore and ferromanganese and currently has the authority to purchase electrolytic manganese metal.*



The platinum group metals. Platinum and palladium are mined, recovered, and recycled here in the US. Other PGM's that are mined in the US are sent elsewhere for recovery. The net import reliance for palladium and platinum is 56%. South Africa dominates global production and is an important source for PGM's to the US along with Russia, Zimbabwe, Canada, Germany, Italy, Switzerland, and the United Kingdom. Supply options for the US to meet increasing demand include further developing the recycling process for recovery of other PGM's and further research into PGM formation in other geologic settings.

USGS Paragraph 2017
PGEs are essential for important industrial applications but are mined in only a limited number of places. Therefore, the availability and accessibility of PGEs could be disrupted by economic, environmental, political, and social events. This is not a new development. During World War I, the United States considered platinum a "vital war material" The most significant primary source of PGEs in the United States is a deposit in the Stillwater Complex, which is a layered igneous intrusion in Montana. Approximately 305 metric tons of platinum and palladium have been mined from the Stillwater Complex deposit since 1986. Exploration and development drilling indicate that another 2,200 metric tons are present. Mining has progressed to depths of 1,800

meters below the surface, but the bottom of the ore deposit has not been reached; geologic estimates suggest that another 1,000 to 6,200 metric tons of PGEs could be present at depth. In the future, PGEs may be mined from deposits found near the base of the Duluth Complex, which is a group of igneous intrusions in Minnesota.

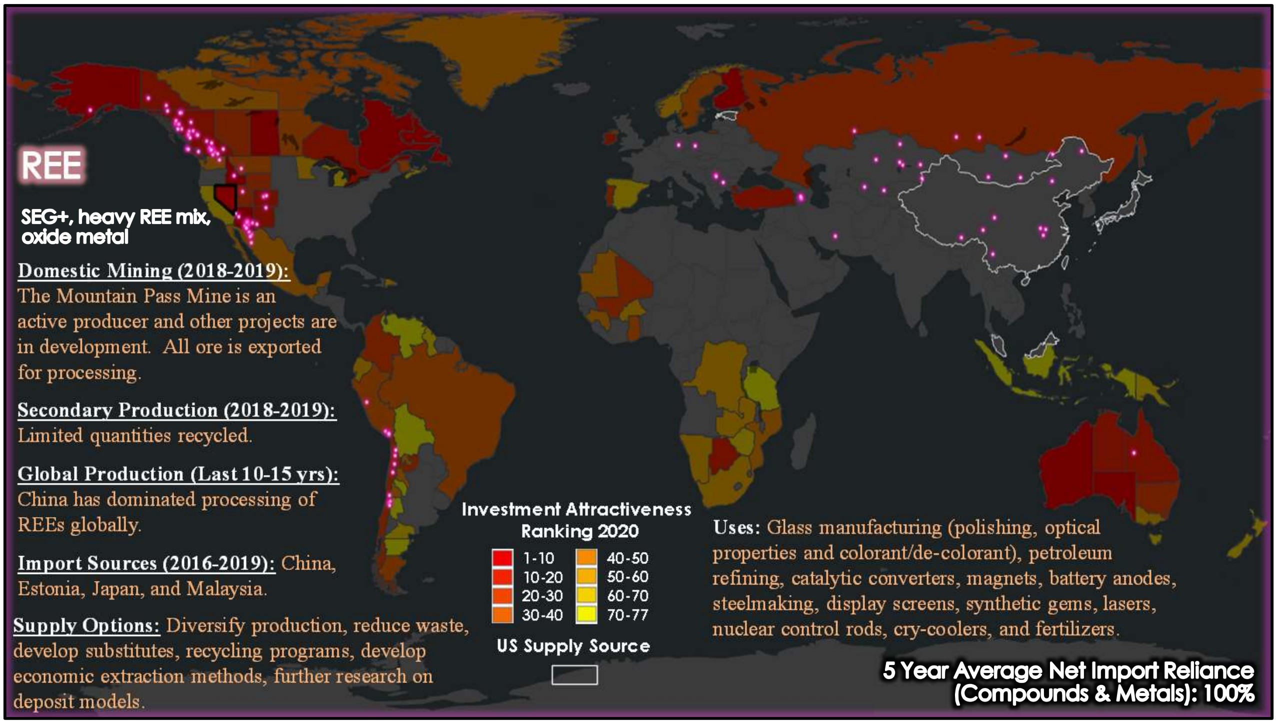


Potash is mined domestically, but production, which has been decreasing, only meets a small fraction of what is needed. There is no domestic secondary production. The average net import reliance during the last 5 years for Potash is 90%. Potash imports have remained consistent for the last 10-15 years with most imported Potash coming from Canada. Efforts to increase supply options include defining more domestic and foreign resources.

USGS Paragraph

Potash is a commodity that encompasses several mined and manufactured salts that contain the element potassium in water-soluble form. Potassium is a critical nutrient for agriculture and is used in various forms in fertilizers. Potash cannot be recycled, but modified farming practices can be used that require less added fertilizer.

The United States produces only a small fraction of the potash needed to meet domestic agricultural consumption and is highly import reliant. However, several countries produce potash, and Canada is the world's leading producer and the dominant import source for the United States. U.S. reserves and resources of potash are very large relative to current consumption.



Rare earth elements. A caveat: this summary is very general, and as indicated in the beginning of this presentation, each of the 15 elements which make up the rare earth element category should be analyzed individually, rather than as a group. Domestic production comes from the Mountain Pass Mine, but all ores are exported for processing. Other rare earth element projects are undergoing development. Limited recycling of batteries, permanent magnets, and fluorescent lamps is a minor domestic source for rare earth elements. The US is 100% reliant on imports. China dominates the processing of rare earth elements globally, and rare earth element compounds and metals are imported from China, Estonia, Japan, and Malaysia. Options to boost domestic supply and decrease foreign reliance include diversifying production, reducing waste, developing substitutes, increase recycling, develop economic extraction methods, and continued research to enhance deposit models.

\USGS Summary
The term "rare earth elements" refers to a group of elements in the periodic table consisting of the lanthanide series (atomic numbers 57–71). Often, scandium (atomic number 21) and yttrium (atomic number 39) are included. In these narratives, cerium, lanthanum, neodymium, praseodymium, samarium, yttrium, and scandium have been discussed separately, and this section will focus on the remaining REEs, which are

europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium. Other than samarium, these are the elements included in what is sometimes referred to as SEG+. These are also sometimes called the mid and heavy REEs. SEG refers to samarium, europium, and gadolinium only.

By weight, these elements account for only 5–6 percent of the total REEs mined, extracted, and separated. However, they are critical for certain niche applications, and in many cases, the best-known substitution options are other REEs.

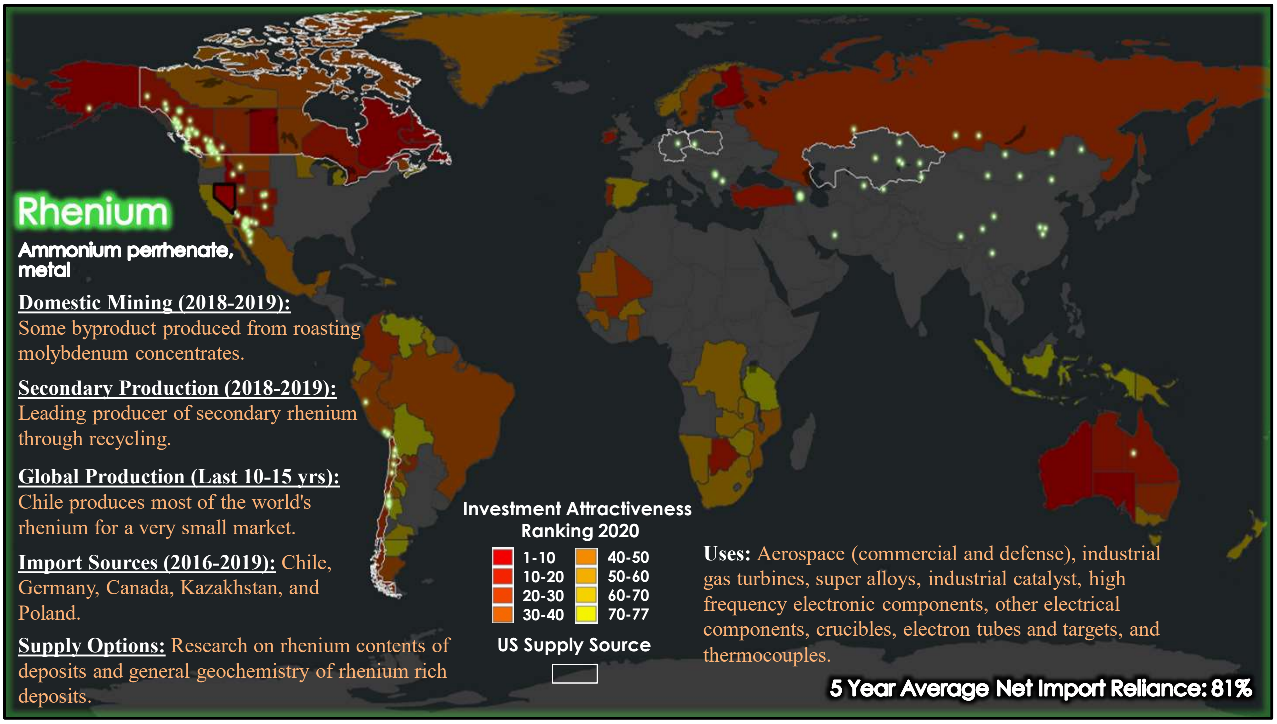
By weight, rare earth permanent magnets are the largest end use for these REEs. In particular, gadolinium, terbium, and dysprosium are used to enhance magnet properties for a subset of NdFeB magnets and samarium-cobalt (SmCo) magnets. Although 10 years ago, options for substitution were lacking for dysprosium use in NdFeB permanent magnets, research efforts, such as the use of grain boundary diffusion methods for production of sintered magnets, have succeeded in decreasing the amount of dysprosium needed.

Gadolinium, erbium, and holmium are commonly used in specialty glass for lasers and fiber optics and for optical glass for lenses used in cameras, microscopes, binoculars, telescopes, and other devices. Europium, gadolinium, terbium, thulium, and lutetium are used in phosphors that are then incorporated into general lighting and backlighting on screens for electronic applications. Other applications include magnetostrictive alloys, such as terfenol-D used in impact sensors and audio transducers, fiber amplifiers, MRI contrasting agents, magnetic refrigeration, and other specialty alloys.

All the REEs are produced predominantly in China. These elements are found in small concentrations in most of the commonly mined rare earth ore bodies containing traditional rare earth minerals such as bastnaesite and (or) monazite. Even in minerals that are rich in heavy rare-earth elements, such as ion adsorption clays found in southern China, the concentration is still less than 50 percent (note yttrium is not included in this section but is often included in the "heavy rare earth" group).

Separating these elements from the rest of the REEs is easier than separating them from each other. As a result, fewer commercial processing plants are able to separate the elements of SEG+ than are able to separate the four lightest REEs (cerium, lanthanum, neodymium, praseodymium).

The challenges in addressing the risks of foreign reliance for REEs, especially these mid to heavy REEs, are significant and are part of a large ongoing effort within the U.S. Government. Addressing the risks is part of the NDS Program, which has purchased SEG for use in a national emergency.

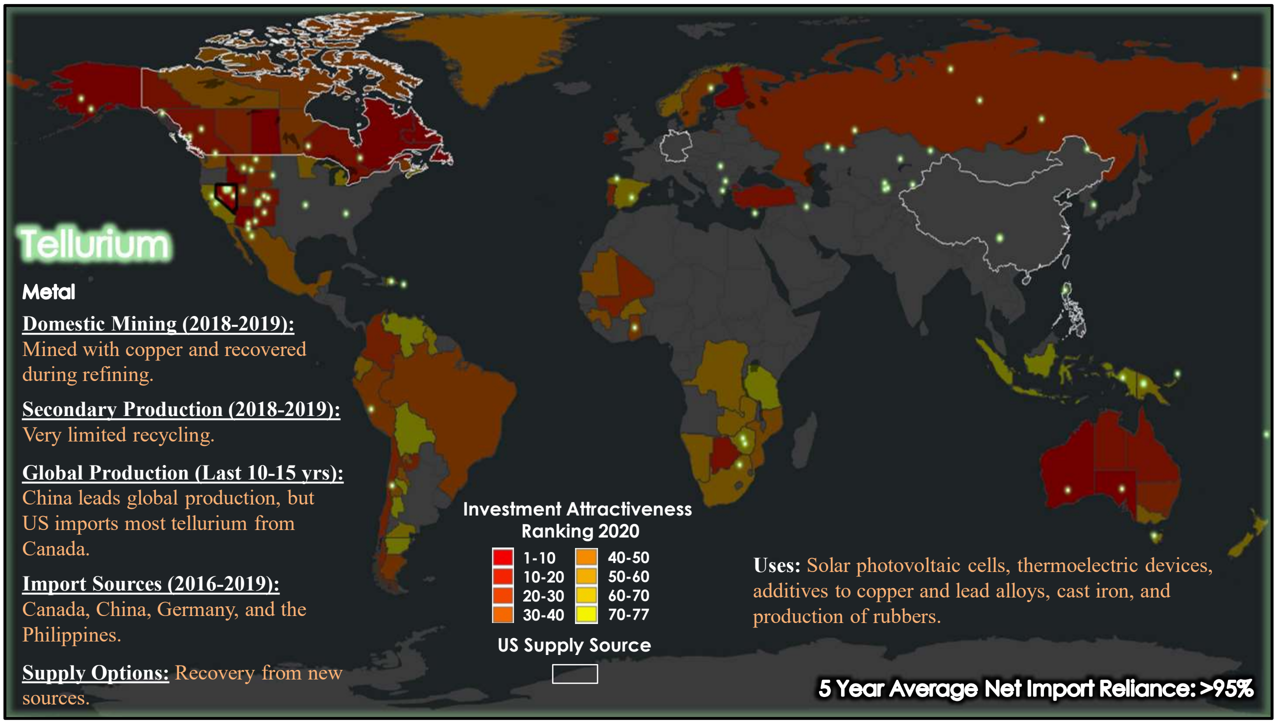


Rhenium. Minor amounts of rhenium are produced from the roasting of molybdenum concentrates. The US is a leading producer of secondary rhenium. The US net import reliance sits at 81%. Chile supplies most of the US rhenium metal powder, where Kazakhstan supplies the majority of ammonium perrhenate. The market for rhenium is still small. Demand is mainly for the production of turbines. Research on rhenium contents in ore deposits and the general geochemistry of rhenium deposits are focal points in attempting to increase or maintain supply.

USGS Paragraph

Rhenium is a critical alloying element used in superalloys, which are largely used in commercial and defense aerospace and industrial gas turbines. The United States is a major producer of superalloys and of turbines, consuming a large fraction of the global rhenium production. Rhenium is also used as an industrial catalyst (particularly in petroleum reforming as a cocatalyst with platinum), in high-frequency electronic equipment and other electronic components, in crucibles for high temperature melts, in electron tubes and targets, and in thermocouples.

The United States produces primary and secondary rhenium but not in sufficient quantities to meet domestic demand. Primary rhenium is produced as a byproduct during the roasting of molybdenite concentrates, which are produced from porphyry *copper-molybdenum ores deposits mined in several U.S. States. Owing to a lack of specialized capability, a notable portion of rhenium-containing, unroasted molybdenite concentrates were exported to other countries where rhenium is recovered, and a portion of the exports was reimported to the United States as rhenium metal. Nearly one-half of the imports are from Chile, and other countries such as Germany, Canada, Kazakhstan, and Poland have supplied the rest of the imports to the United States. Chile produces most of the world's rhenium, with Poland and the United States producing significant quantities as well. The quantity recycled in the Unites States from spent catalysts, superalloy foundry scrap revert (new scrap), and end-of-life gas turbine parts is thought to be significant, but data were not reported. Reserves of rhenium are large compared to annual production.*



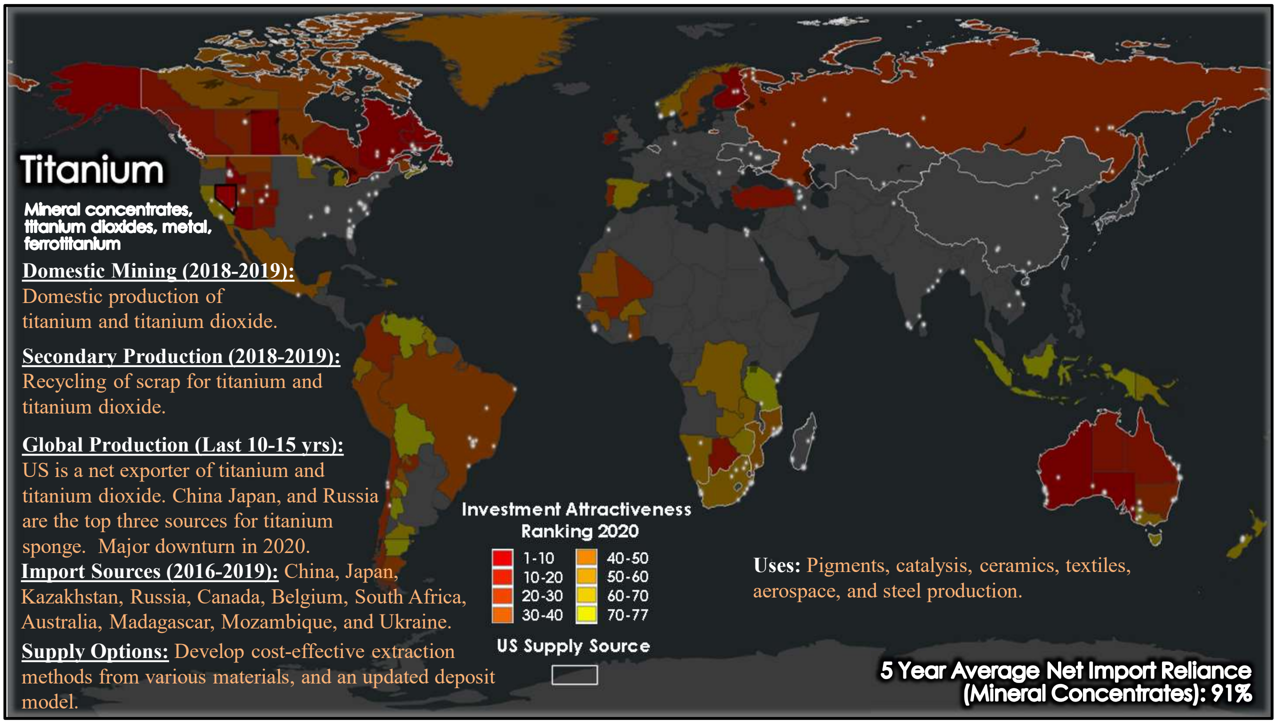
Tellurium. Some tellurium metal is mined with copper and is recovered during refining. There is very limited recycling in the US, leaving the average net import reliance greater than 95%. Most tellurium is imported from Canada, China, Germany, and the Philippines. According to the USGS "In the near future, recovery of lower copper grades may force recovery of oxidized copper ores by solvent extraction; in this process, it is not possible to recover the tellurium as a byproduct, as is possible through the smelting of higher-grade copper sulfide concentrates. This change in method could potentially lead to a greater emphasis on precious-metal deposits to meet global and domestic tellurium demands. And future research may focus on methods to recover tellurium from two new sources one being the extraction of tellurium from iron-manganese crusts on the ocean floor, and the second being the reprocessing of old waste piles."

USGS Paragraph

Tellurium's major use has changed over the past 10 years (2010–19). Previously, it was used mostly as an alloying additive in steel to improve the machining performance of steel. However, it now is used primarily in solar photovoltaic cells, specifically for cadmium telluride cells. Other applications include thermoelectric devices for cooling and energy generation; additives to copper alloys, lead alloys, and cast iron; and in the production of rubber.

In the United States, tellurium is mined with copper and recovered during the refining process; it ends up largely in copper anode slimes. Recovery of tellurium from the slimes has not been commercially viable domestically, and some of it is thought to be exported to be refined to metal outside the United States. Some recycling is thought to occur domestically, but many applications that use tellurium are dissipative; therefore, it is not easily recycled.

Although production data are scant, China is thought to produce more than one-half of the world's refined tellurium, with Japan, Sweden, Russia, and Canada producing most of the rest. The United States imports tellurium largely from Canada, although the reported imported quantities are potentially misleading because they exceed the reported quantity produced in Canada. As with many other minor metals, tellurium supply and demand data are of poor quality and not readily available.



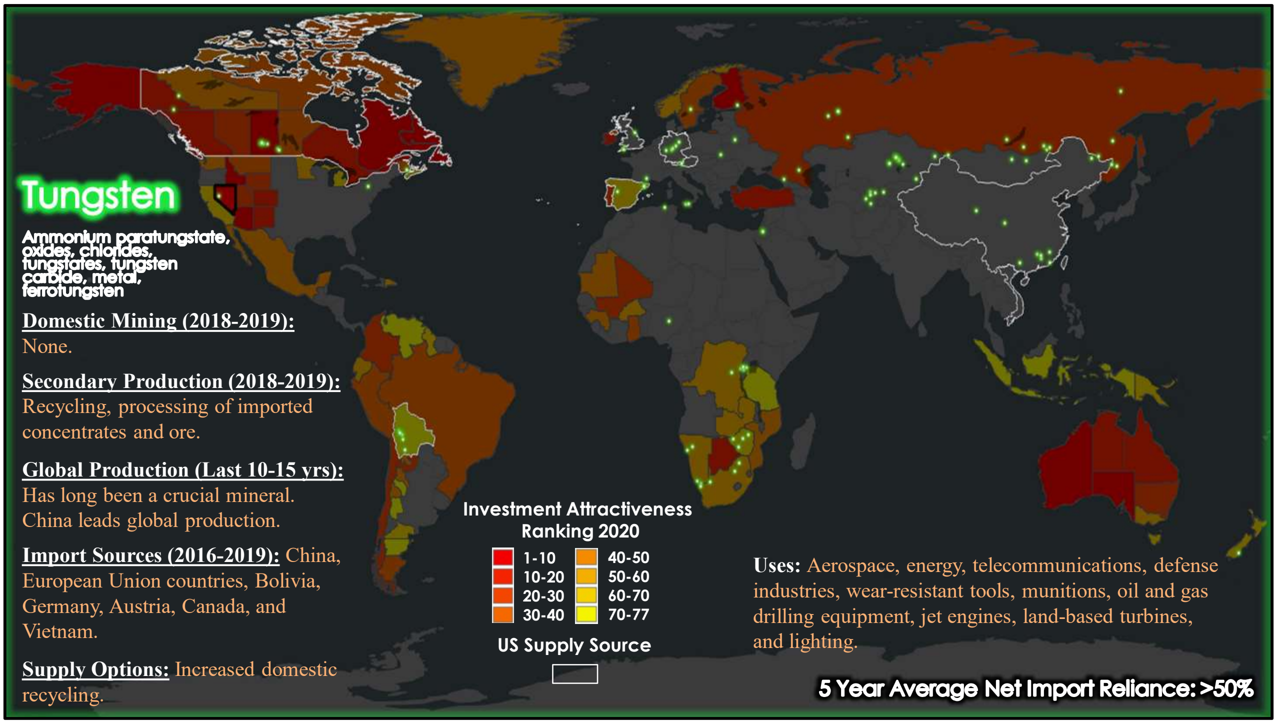
All forms of titanium deemed critical are produced domestically and titanium scrap is imported for secondary production of titanium and titanium dioxide. Though the US is a net exporter of titanium dioxide and metal ingot, the 5-year average net import reliance for mineral concentrates is 91%. Sources for titanium come from several regions listed on the screen.

USGS Paragraph

Titanium mineral concentrates are mined and processed into titanium dioxide and titanium sponge metal. Titanium dioxide is used to produce pigments for paints, coatings, plastics, rubber, paper, and other uses. Titanium dioxide also is used in catalysts, ceramics, and textiles. Although by tonnage, titanium metal accounts for only about 10 percent of titanium mineral concentrate consumption, it is critical to the aerospace industry owing to its high strength-to-weight ratio and corrosion resistance. Titanium metal also is used in steel production for high-strength low-alloy steels and stainless steels.

The United States has the capability to produce titanium in various forms and to recycle titanium scrap. However, although the United States is a net exporter of titanium dioxide and metal ingot, it is highly dependent on imports for titanium mineral concentrates and sponge metal. Moreover, sponge metal production capacity is limited to two domestic

facilities and China, Japan, Kazakhstan, Russia, and Ukraine. The collapse of demand for commercial aerospace products in 2020 caused domestic titanium demand to decline and in turn affected domestic producers.
Domestic reserves of titanium minerals are significant, although the size of domestic resources of titanium minerals is not well quantified. Titanium is currently among the metals listed in the Specialty Metals Clause, 252.225-7009 Restriction on Acquisition of Certain Articles Containing Specialty Metals. The NDS holds titanium alloys for national emergency purposes.



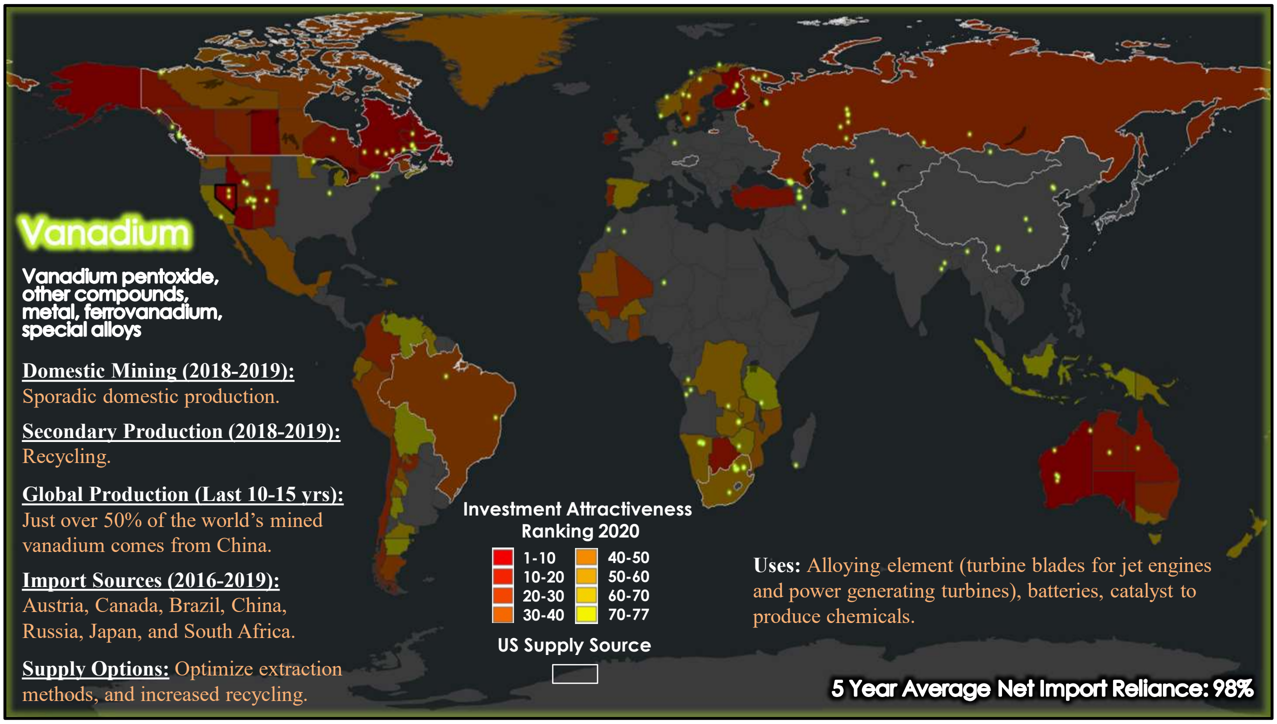
Tungsten. Domestic commercial production of tungsten has not taken place since 2015. There is some recycling and significant processing of imported ores and concentrates. Our net import reliance sits at less than 50%. China leads global production for all forms of tungsten and is who we source much of our tungsten from. Increasing domestic recycling would assist in maintaining supply.

USGS Paragraph

Tungsten is used in the aerospace, energy, telecommunications, and defense industries. Tungsten carbide is used in wear-resistant tools, munitions, and oil and gas drilling equipment. When added to superalloys, it is used in jet engines and land-based turbines. Its high melting temperature is important for use in lighting and specialty filaments. It has consistently been identified as a strategic and critical material by the Defense Logistics Agency–Strategic Materials, the manager of the NDS Program.

The United States relies on foreign sources for many of its tungsten forms, including ore and concentrate, ammonium paratungstate (APT), tungsten carbide, tungsten metal powders, and ferrotungsten. Across the tungsten supply chain, China leads global production, accounting for more than one-half of production of each form of tungsten. The United States depends significantly on imports from China to supply its manufacturing base, although imports of various forms of tungsten come from European

Union countries, Bolivia, Canada, and Vietnam. Multiple domestic producers make APT from concentrates or scrap; however, only one domestic operation produces ferrotungsten. No tungsten ores or concentrates are produced domestically, although mines have operated in the past. The NDS holds tungsten ores and concentrates, tungsten metal powders, and tungsten-rhenium metal alloy.

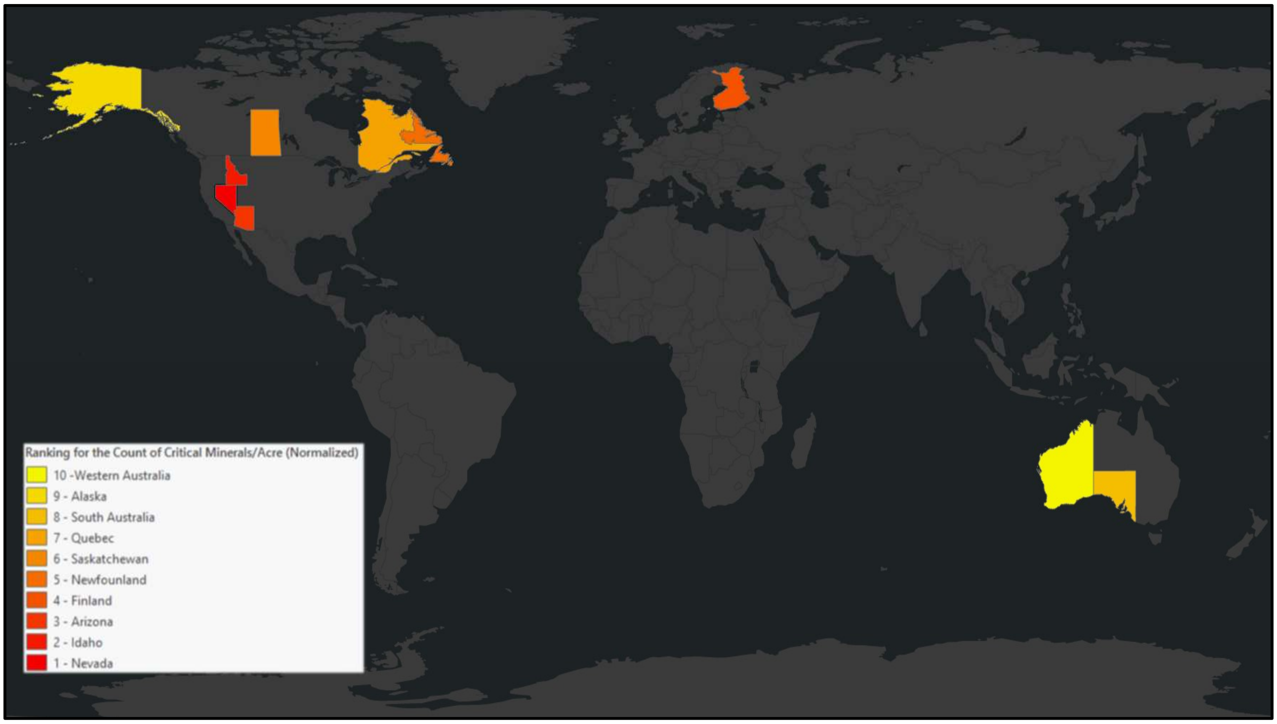


And finally, the last critical mineral we will review is Vanadium. There has been sporadic domestic mining of vanadium, and some recycling. The average 5-year net import reliance is 98%. China is responsible for over half of the world's mined vanadium. Austria has been the most important import source for ferrovanadium and Brazil for Vanadium pentoxide.

USGS Paragraph

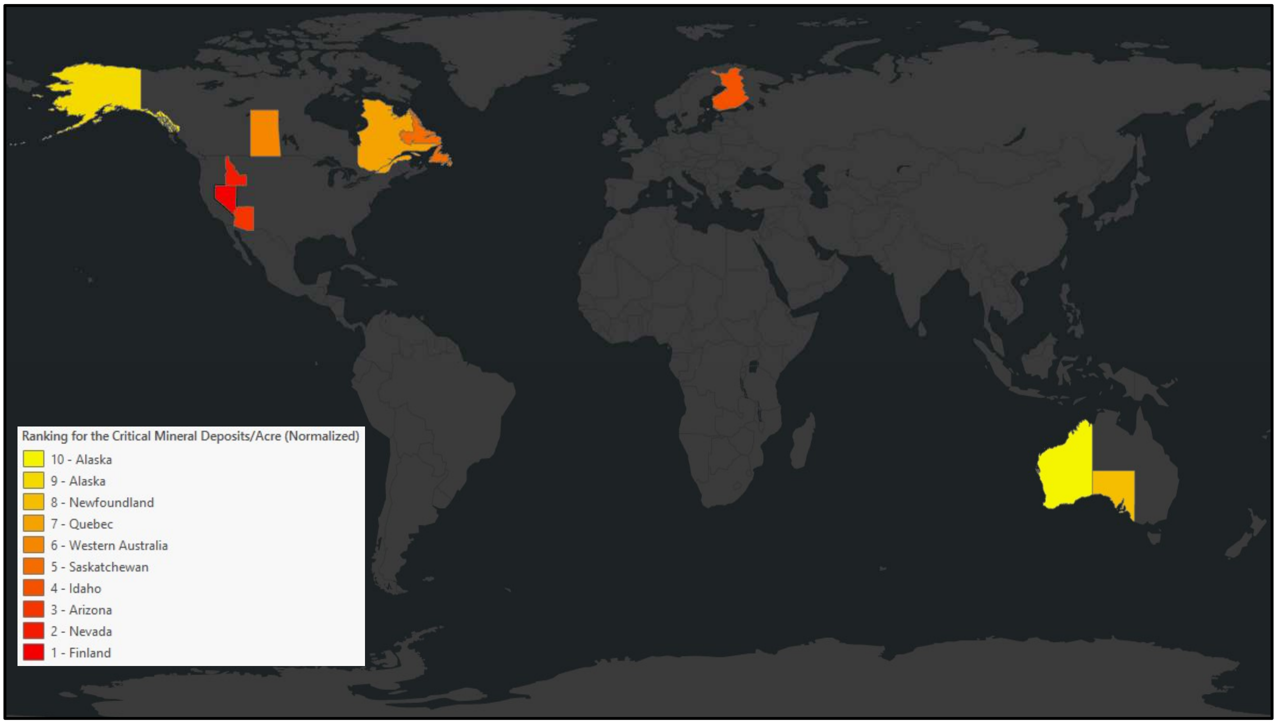
Vanadium metal is predominantly used domestically as an alloying element in applications such as turbine blades for jet engines and power generation turbines. Vanadium is also used in batteries for large-scale electricity storage and as an industrial catalyst to produce chemicals. Substitution is possible for some alloys, such as in steel, where manganese, molybdenum, niobium, titanium, and tungsten could potentially replace it. For aerospace titanium alloys, substitution may not be feasible without research and testing.

During the past 10 years, vanadium has been mined sporadically in the United States. The domestic supply chain includes processing and recycling of vanadium, sometimes from imported materials, for which quantitative data are lacking. Many forms of vanadium are traded globally, but about one-half of the imports to the United States are in the form of ferrovanadium and vanadium pentoxide, both of which are sourced from a *several countries, including Austria, Brazil, China, Russia, and South Africa. China and Russia are the world's leading producers of mined vanadium, together accounting for more than 80 percent of the world's mined vanadium.*



We took the 10 highest rank jurisdictions, as far as investment attractiveness and within each, tallied the mines, deposits, and plants for each critical mineral we just discussed. Again, only using the USGS data outlined in the seventh slide.

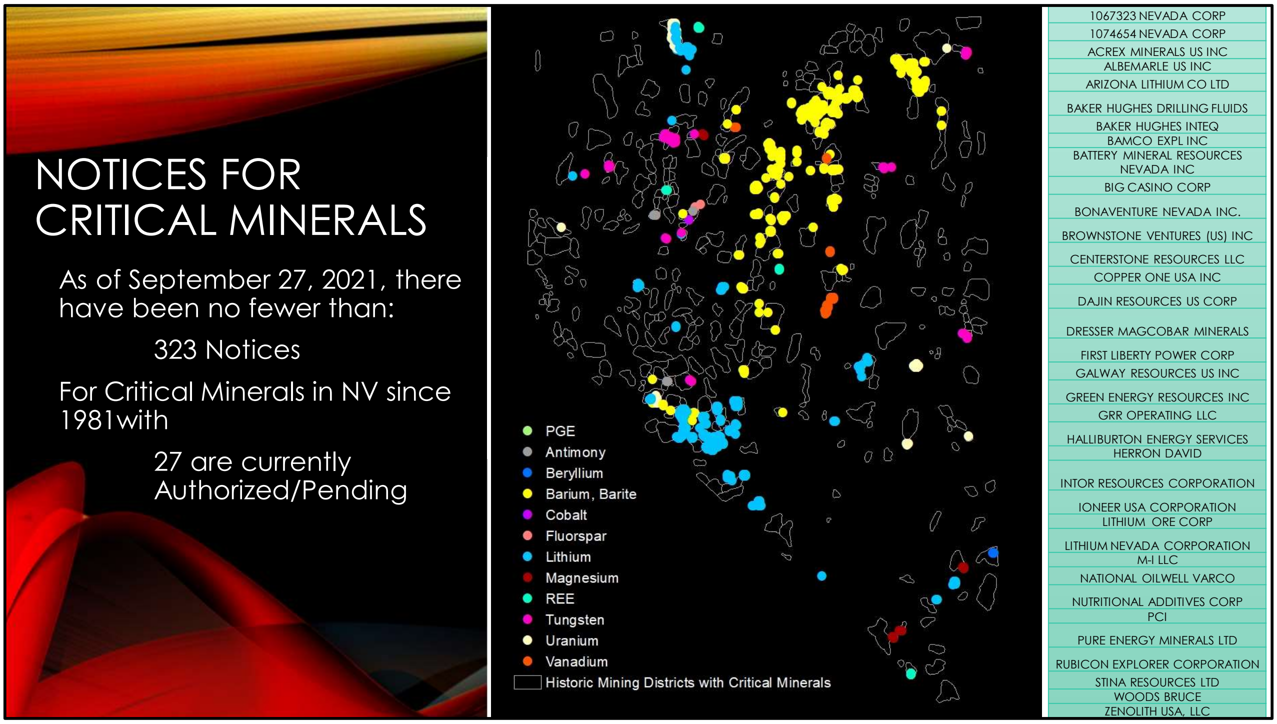
If we look at the count of critical minerals per acre that occur within a jurisdiction, Nevada comes in first followed by Idaho and Arizona.



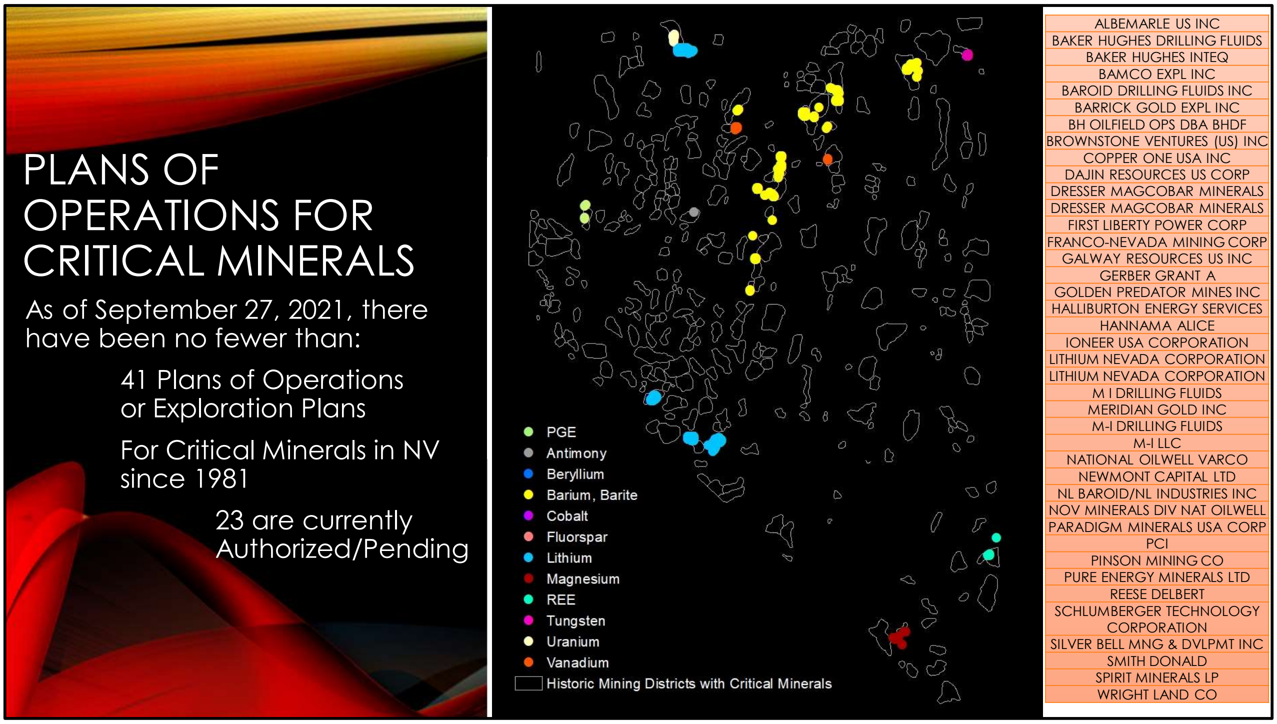
If we look at the number of critical minerals deposits per acre that occur within a jurisdiction, Finland comes in first followed by Nevada and Arizona. Finland jumps into first place here because there are 29 platinum group metal deposits documented within this region.

Bottom line…Nevada appears to be a good place to be exploring for critical minerals.

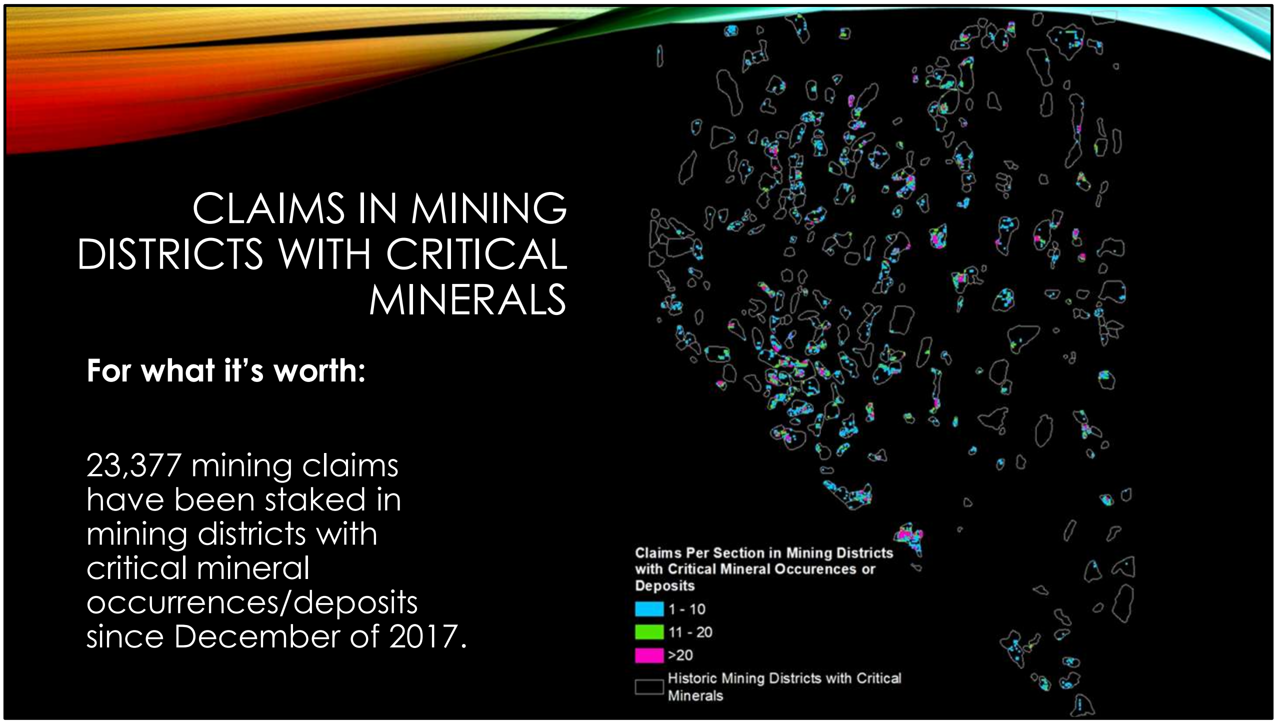
So, with that, Let's bring our focus back to Nevada and review a little bit about current critical mineral activity in the state, work involving critical minerals from government and state agencies, and conclude with some data resources.



Since 1981, there have been no fewer than 323 notices filed with the BLM, with the commodity of interest being one of the critical minerals identified in the 2018 federal register list. Keep in mind…the commodity of interest isn't always specified, so no fewer seems like a pretty accurate statement. Currently, there are 27 of these notices whose disposition is authorized or pending. The claimants and/or operators of these authorized notices are listed in the table shown on the right.

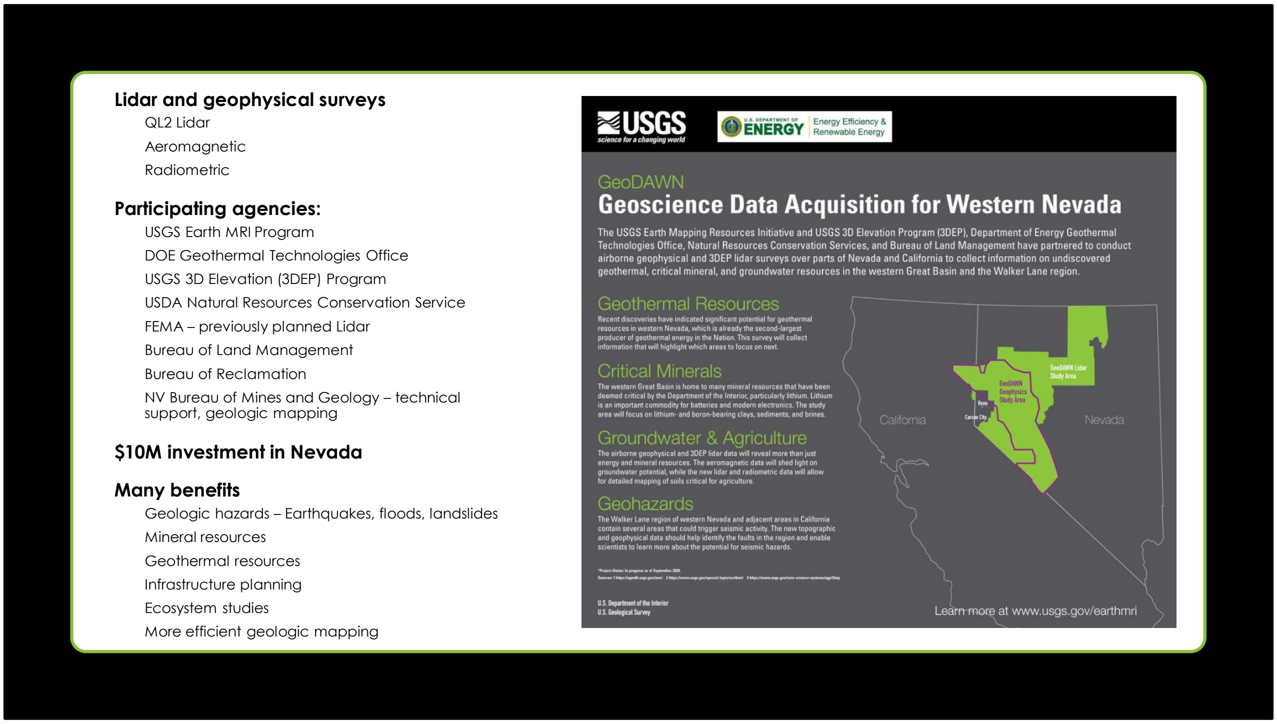


Since 1981, there have been no fewer than 41 mine or exploration plans filed with the BLM, with the commodity of interest being one of the critical minerals from the 2018 federal register list. Again, the commodity of interest is not always, or has not always been disclosed. Currently there are 23 of these plans whose disposition is authorized or pending. The claimants and/or operators of these authorized notices are listed in the table shown on the right.

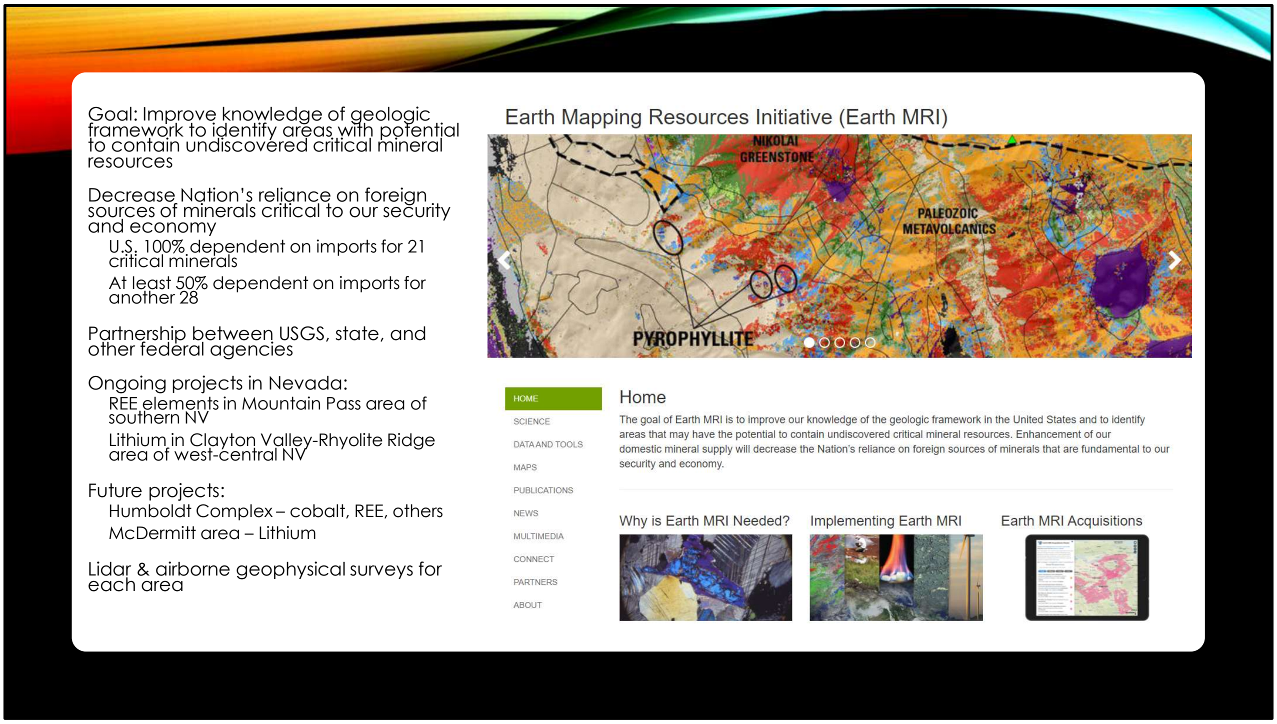


For what it's worth:

23,377 mining claims have been staked in mining districts with critical mineral occurrences/deposits since December of 2017.



At the state and federal government level there are two large projects in progress that pertain to critical minerals. The first is the Geoscience Data Acquisition of Western Nevada or GeoDAWN. Several agencies, both federal and state are participating in this project that focuses on conducting airborne geophysical and 3DEP (three-dimensional-elevation program) lidar surveys over Nevada and California in an effort to collect information on undiscovered geothermal, critical mineral, and groundwater resources in the western Great Basin and the Walker Lane region. There has been a 10-million-dollar investment in Nevada to meet the project goals which has many benefits as highlighted on the screen. The Nevada Bureau of Mines and Geology is actively involved in this project.

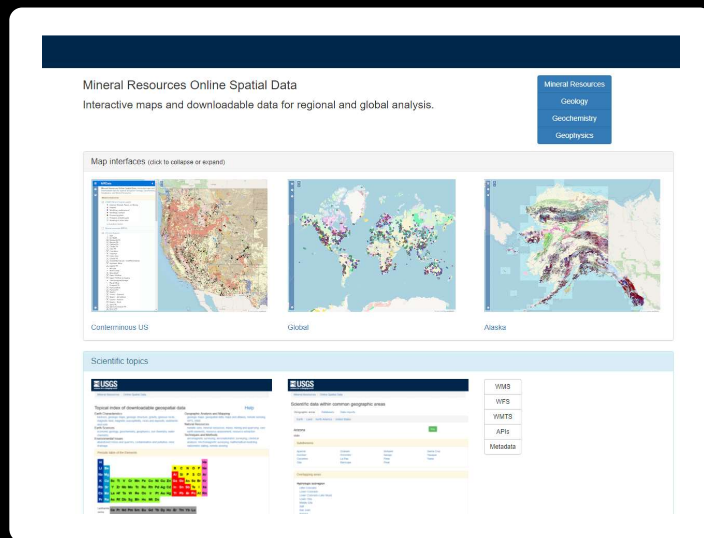


The second project involving critical minerals at the state and federal government level is the Earth Mapping Resources Initiative or Earth MRI. The goal of this project is to improve knowledge of geologic framework to identify areas with potential to contain undiscovered critical mineral resources and to decrease the Nation's reliance on foreign sources of minerals critical to our security and economy. This project consists of a partnership between the USGS, state and other federal agencies. There are two ongoing projects and two documented future projects that the Bureau of Mines and Geology will be participating in the Mountain Pass, Clayton Valley-Rhyolite Ridge, the Humboldt Complex and McDermitt area respectively.

MRDATA - USGS

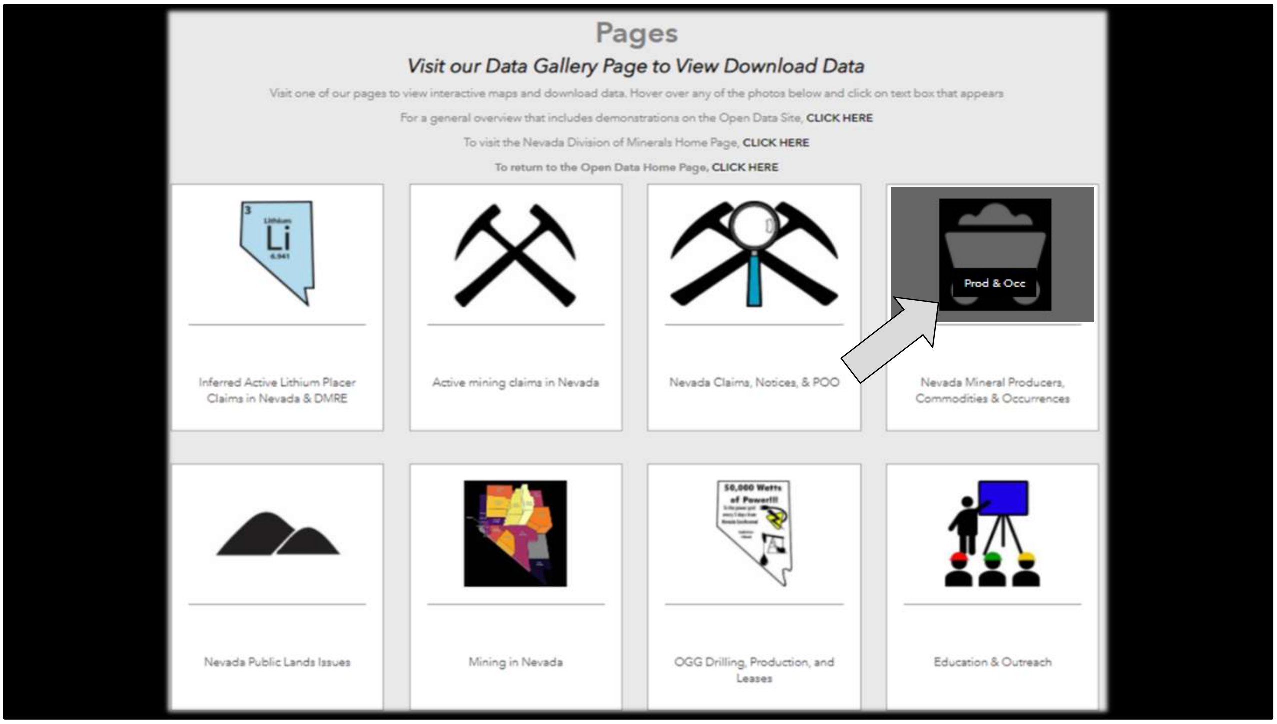
USGS online spatial data

- Interactive Maps
- Mineral Resources
- Geology
- Geochemistry
- Geophysics
- Geochronology

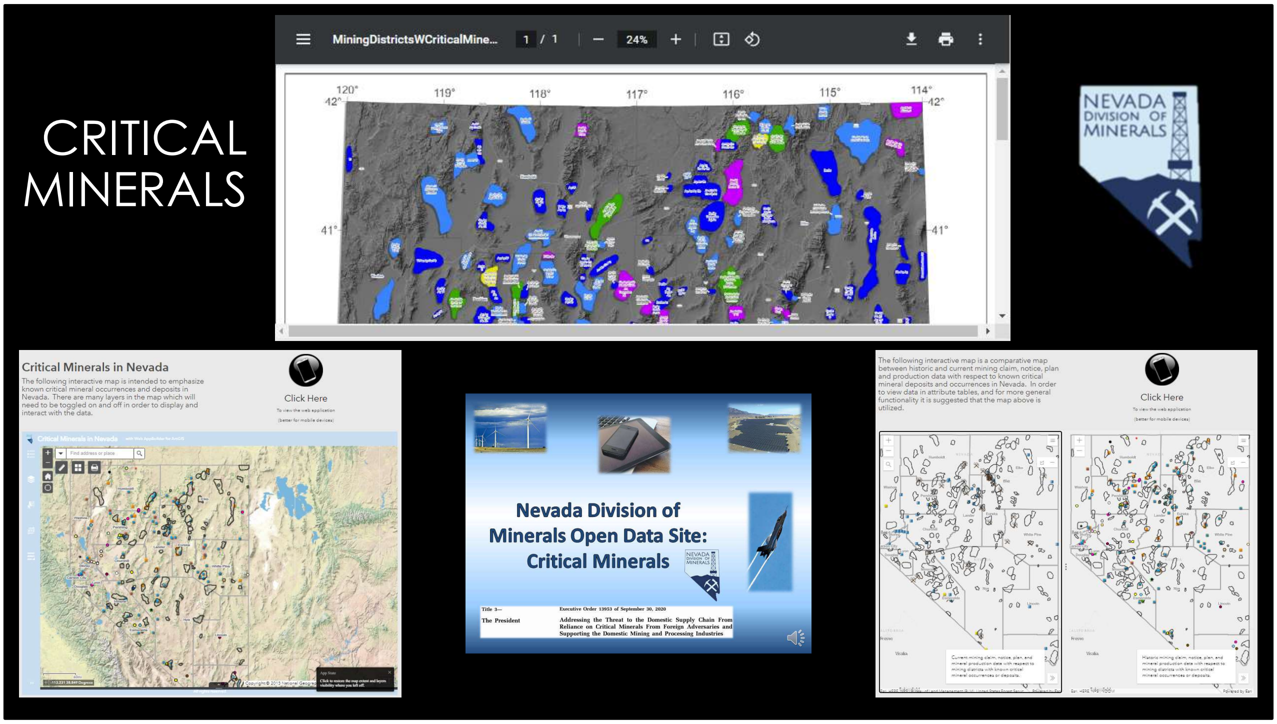


Onto data resources. First stop, Mr. Data The USGS Mineral Resources Online Spatial Data site. This is the source for most geospatial data shown in this presentation. There is a variety of good geospatial data that is possibly dated, but free to use here. Types of data include mineral resource, geological, geochemical, geophysical, and geochronological downloadable data.

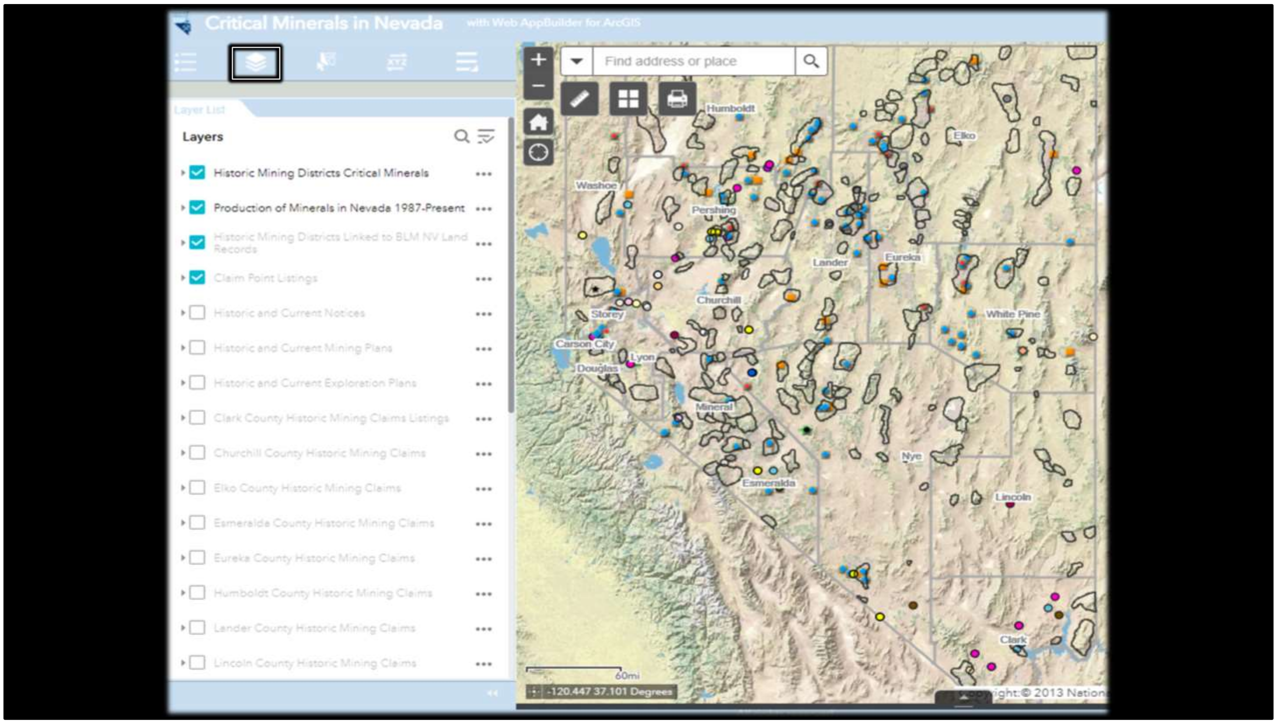
Here at the division, we have put together some web maps that focus on critical minerals.



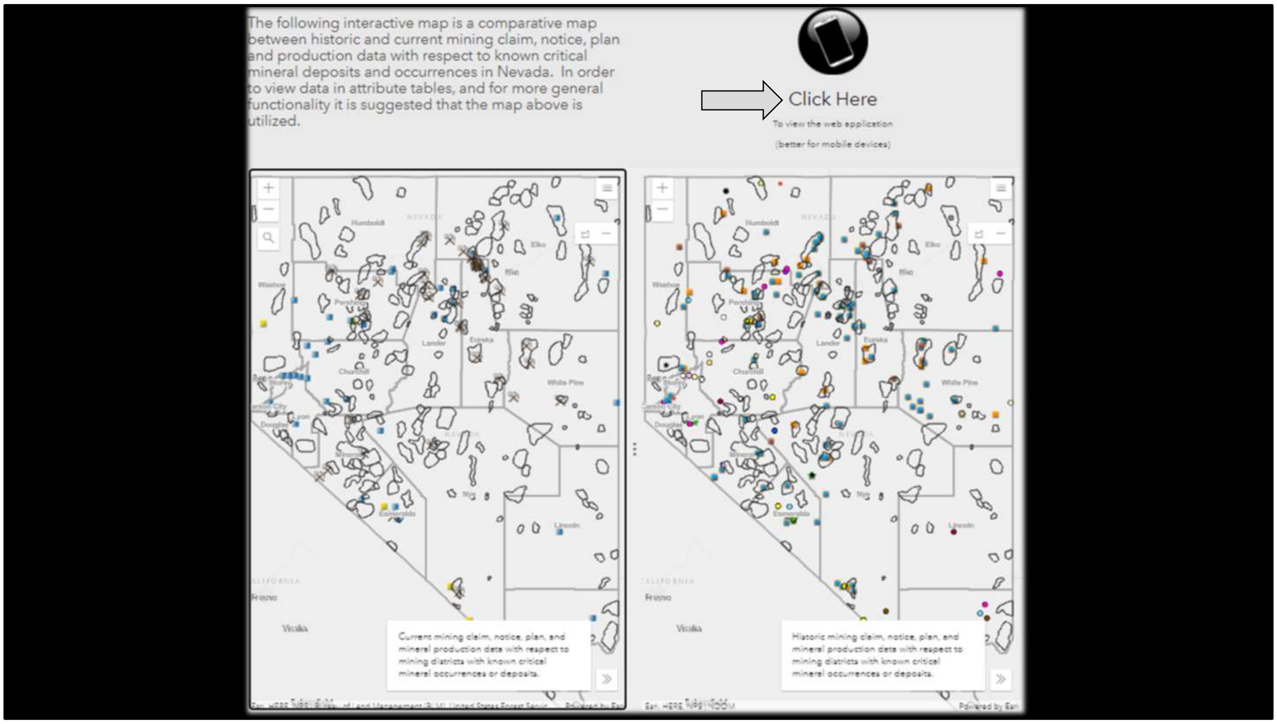
To access the content, scroll down to the "Pages" listing section of the home page and click on the Nevada Mineral Producers, Commodities and Occurrences page.



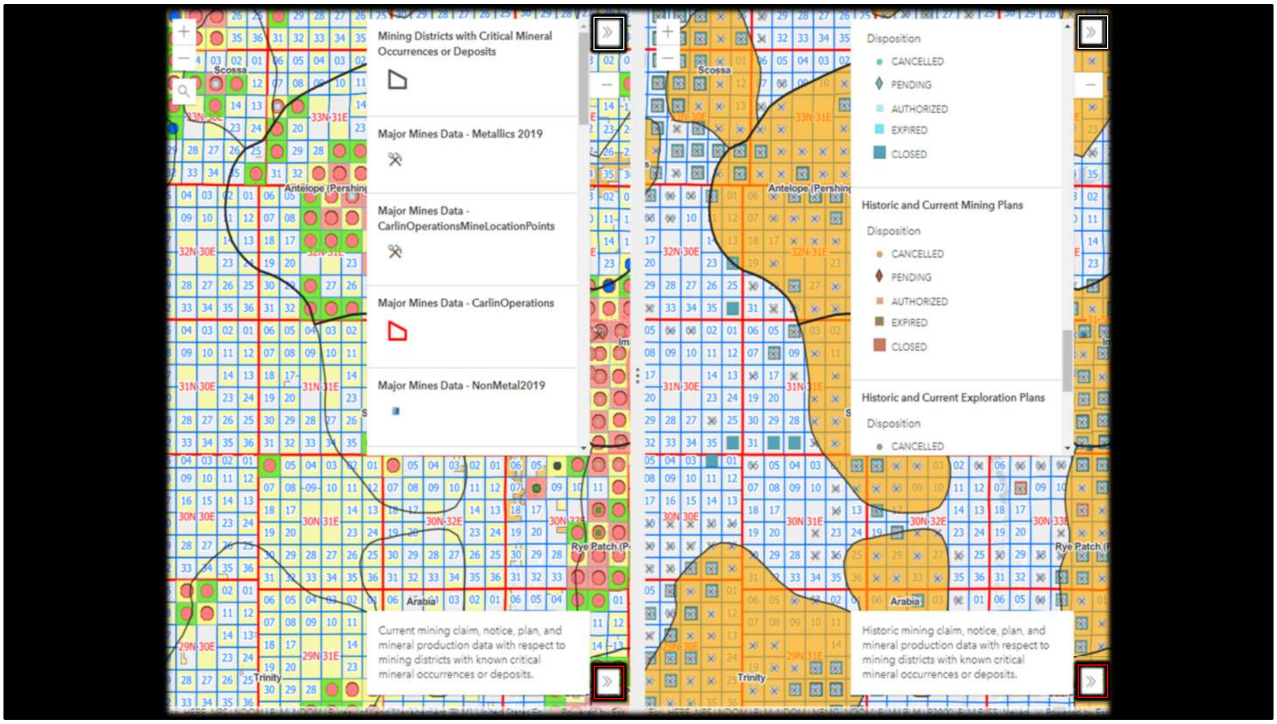
If you scroll down towards the bottom of this page you will come to the critical minerals section, where you will find a video tutorial for the web applications we are about to review, two interactive web maps, and a couple pdf maps, including the colorful mining districts map shown earlier in this presentation.



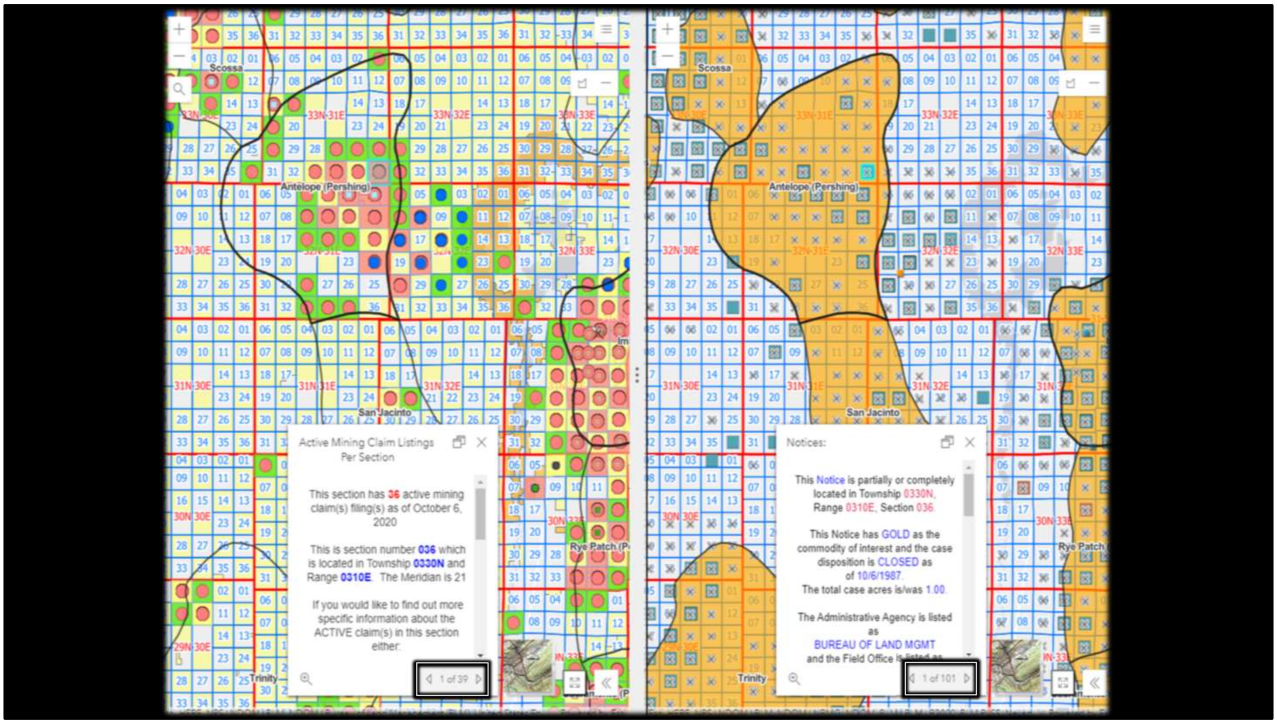
This is the first web map you will come to. This map contains historic-mining-claim listings, notices and plans along with Tingley's historic mining district data, which has been filtered to display those with Critical Minerals occurrences or deposits. And of course, all maps are interactive and have popups which give more information on the features presented within.



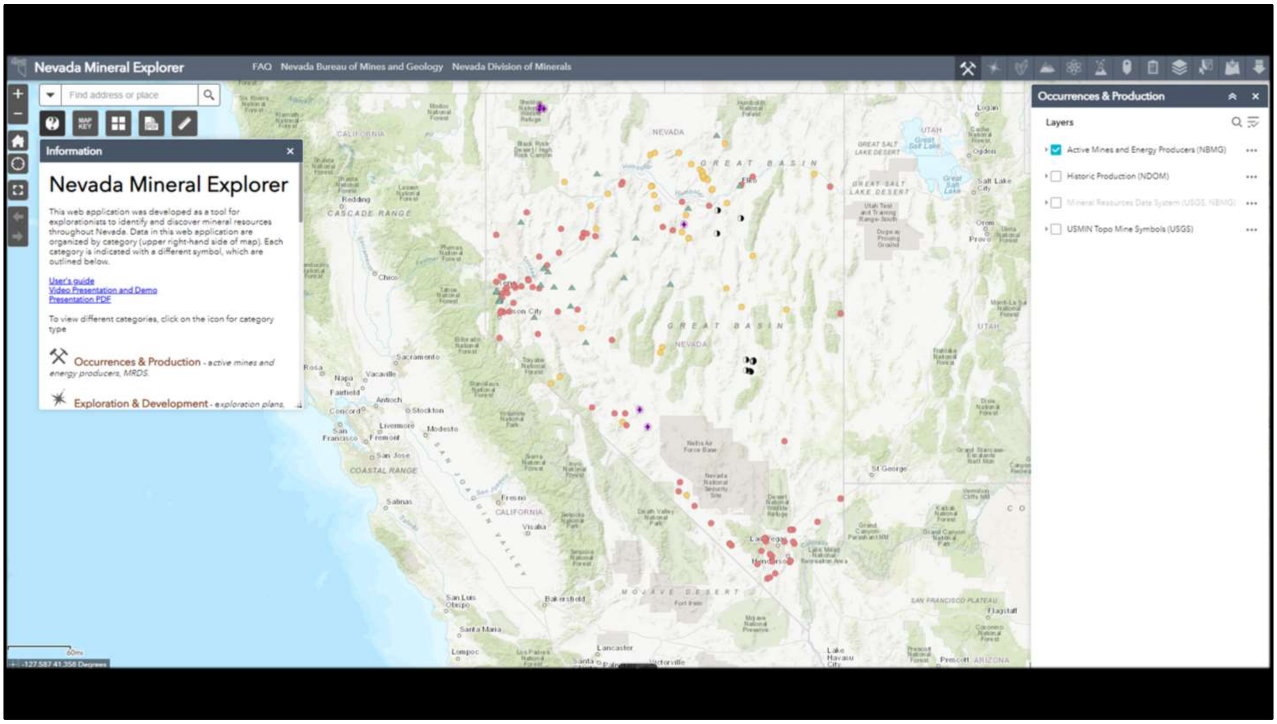
Scrolling down below this map you will come to another web mapping application which will compare current and historic data with respect to mining districts known to contain deposits or occurrences of critical minerals.



When we zoom into the map, current mining claims point listings, mining claims per section, major mines and authorized or pending notices and plans render on the left map panel. In the right-hand map panel, historic mining claim point listings and any notices that are closed, cancelled, or expired are displayed. Map extents will always mirror one another. The legend can be displayed by clicking the double arrows outlined in blue in the upper right-hand corner of the map panels. The information box can be minimized by clicking the double arrow to the right of the box which is outlined in red. We will minimize the legend and the information box.



We will click on some points within the map, and you can see our familiar popups appear. Unfortunately, viewing mass amounts of data using this application is a bit cumbersome, as one cannot view the data in an attribute table. For the option to view attribute tables, and for more general functionality, the map we previously discussed is recommended. But, this comparative map is great for looking at a lot of data on one screen. The popup can be toggled into a list view by clicking on the number of records selected in the bottom right-hand corner of the popup, which is outlined in blue.



And finally, don't forget about the Nevada Mineral Explorer, which is a web application developed by the Nevada Bureau of Mines and Geology and the Nevada Division of Minerals as a tool for explorationists to identify and discover mineral resources throughout Nevada. This application was created to be a one-stop-shop for explorers to view and interact with data relevant to Nevada geology, mining, precious metals, industrial minerals, geothermal resources, along with oil and gas. Data has been gathered from various sources, including the Nevada Division of Minerals, the Nevada Bureau of Mines and Geology, the USGS, BLM, and USFS.

And that is the end of my presentation. Thank you.