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Testimony on Critical Minerals and Materials Legislation
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE
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My name is Jonathan G. Price. I am the Nevada State Geologist and Director of the Nevada Bureau of Mines and Geology, which is the state geological survey and a research and public service unit of the Nevada System of Higher Education at the University of Nevada, Reno. I am testifying today from my perspectives as State Geologist and as the Co-Chair of a 2011 study on *Energy Critical Elements: Securing Materials for Emerging Technologies* by the American Physical Society's Panel on Public Affairs and the Materials Research Society. A copy of this study is appended to my testimony.

Thank you for this opportunity to comment on the issues of critical minerals and the three bills that you are considering.

Four graphs at the end of this testimony provide some context for the issues. Global demand for nearly every mineral and energy commodity is rising, in part because global population is rising and in part because average standard of living is also rising. Neither copper nor iron are considered critical minerals in most discussions today, because their resources are widely distributed geographically, and markets for them are well established, but they help provide context on the rising demand for the minerals that are considered critical or strategic. The continuing historical rise in demand for copper, an example of a mineral commodity needed for modern society, is documented in Figure 1. To meet global demand, the world needs to mine the equivalent of one huge copper deposit each year and find a new one to replace the depleted reserves. Although conservation and recycling can lessen the demand for newly mined copper, the increases in both global population and average standard of living require more mining.

Domestic resources for most, but not all, mineral commodities occur in the United States, where they are mined using the world's best practices for environmental stewardship and health and safety for workers and the public. The Federal government (specifically through the U.S. Geological Survey in the Department of Interior for most mineral resources and through the Department of Energy for some of the energy resources) has a vital role in documenting domestic production and reserves and in assessing the likelihood of future discoveries that will add to the mineral and energy resources of our country.

Global iron-ore production and, by that measure, the rise of China as a major economic power, is shown in Figure 2. The dominance of China as a producer of mineral and energy commodities today is illustrated in Figures 3 and 4. These graphs use critical data collected and reported by the USGS. China's dominance in the minerals arena presents challenges, threats, and opportunities for the United States.

The world isn't running out of mineral resources; long-term demand will likely be met by supplies from a global free market. The resources are, however, unevenly distributed geologically and geographically, such that short-term supplies of raw materials and value-added manufactured products can be and have been interrupted, leading to price increases that can be significant concerns for the U.S. economy and the economies of other, less mineral-rich countries.

The report on *Energy Critical Elements: Securing Materials for Emerging Technologies* (the ECE report) surveys potential constraints on the availability of these elements. Energy-critical elements (ECEs) are a class of chemical elements that currently appear critical to one or more new energy-related technologies. A shortage of these elements would significantly inhibit large-scale deployment, which could otherwise be capable of transforming the way we produce, transmit, store, or conserve energy. The report addresses elements that have not been widely extracted, traded, or utilized in the past, and are therefore not the focus of well-established and relatively stable markets. The report discusses a number of constraints on the availability of ECEs for the U.S. and world markets:

(a) Crustal abundance, concentration, and distribution. Whereas exploration benefits from well-tested geological models of ore deposits for the more common metals, such understanding is lacking for many of the less common elements.
(b) Geopolitical risk. The production of some ECEs is dominated by one or a few countries.
(c) Risk of joint production. Tellurium and selenium are good examples of ECEs that are produced as byproducts of a more common metal – copper. There is little incentive to increase the production of these byproduct metals, as long as their prices remain low relative to their abundances.
(d) Environmental and social concerns. As countries that now have lax environmental, safety, health, and social impact standards embrace higher standards, the price and availability of ECEs may be significantly affected.
(e) Response times in production and utilization. The time period from exploration to production is commonly 5 to 15 years or longer, and there are similarly long timeframes, sometimes decades, for bringing a new technology, such as a new choice of elements for photovoltaics, to market.

The report identifies five specific areas of potential action by the United States to insure the availability of ECEs:

(1) Federal agency coordination;
(2) information collection, analysis, and dissemination;
(3) research, development, and workforce enhancement;
(4) efficient use of materials; and
(5) market interventions.

Recognizing that the Department of Defense is responding to the 2008 National Academy of Sciences report on *Managing Materials for a Twenty-first Century Military*, the ECE report did not address military/defense stockpile issues, and apart from helium, which has special physical and geological properties, did not recommend stockpiles of ECEs for purely economic reasons.

The bills currently pending in the Senate – S. 383, S.421, and S.1113 – do an excellent job of addressing many of the recommendations made in the ECE report, but some changes, following recommendations in the ECE report, could make the legislation even more effective. Specifically:

(1) S.383 and S.1113 have sections covering information collection, analysis, and dissemination. The ECE report, as well as a 2008 National Academy of Sciences report on *Minerals, Critical Minerals, and the U.S. Economy*, recommended that the USGS (or whatever agency is given the primary responsibility for mineral-resource data collection and analysis) be given more authority and elevated to a "Principal Statistical Agency," as is the Energy Information Administration in the Department of Energy. This designation could be added to S.1113 (Sec. 103–Resource Assessment or Sec. 107–Analysis and Forecasting) or S.383 (Sec. 3).

(2) All the bills establish research and development programs, and S.383 and S.1113 address workforce issues. However, the ECE report recommended a somewhat broader research spectrum than the bills that have been introduced. In our view,

> "the Federal government should establish an R&D effort focused on ECEs and possible substitutes that can enhance vital aspects of the supply chain, including geological deposit modeling, mineral extraction and processing, material characterization and substitution, utilization, manufacturing, recycling, and life-cycle analysis."

(3) S.383 and S.1113 include sections dealing with research on efficient use of materials (recycling, substitutions, etc.). The ECE report included an additional recommendation regarding recycling:

> "Steps should be taken to improve rates of postconsumer collection of industrial and consumer products containing ECEs, beginning with an examination of the numerous methods explored and implemented in various states and countries."

S.1113 appropriately recognizes the value of having the USGS and DOE work with State geological surveys on resource assessments (Sec. 103). The State geological surveys often have critical-mineral data, geological samples available for research, and expertise that are not easily accessible to the USGS. For example, Peter Scholle, the New Mexico State Geologist, and Virginia McLemore, economic geologist on their staff, informed me about New Mexico's data on rare earth elements, tellurium, beryllium, and other resources, and Robert Swenson, the Alaska State Geologist, noted that their efforts have made new information about Alaskan resources, including platinum-group elements, readily available for follow-up by industry. In Nevada, currently the U.S.'s only lithium producer, our State geological survey houses considerable information on the geologic framework for lithium deposits. At the University of Nevada's Mackay School of Earth Sciences and Engineering, in a joint project with the USGS, we are using samples from the Mackay-Stanford Ore Deposits Collection to begin to understand the distribution of tellurium and selenium in both domestic and international copper deposits. The coastal Atlantic States, from Florida to Maine, have data on offshore and near-shore resources of heavy mineral sands, which need to be included as long-term resources for rare earth elements, titanium, zirconium, and other potentially critical minerals.

It would be appropriate for Section 104 of S.1113, which deals with permitting issues, to specifically identify State regulators as stakeholders with whom the Federal Critical Minerals

Working Group should consult. In many states, including Nevada, State and Federal regulators try to work together to speed up the permitting process, but the slowness of permitting, particularly on Federally managed lands, continues to be a major deterrent for domestic exploration and production.

Section 102 (Policy) of S.1113 encourages "Federal agencies to facilitate the availability, development, and environmentally responsible production of domestic resources to meet national critical minerals needs." This wording is consistent with the June 2011 statement by the Society for Mining, Metallurgy, and Exploration concerning rare earth elements:

> "It is critical to establish a domestic rare earths minerals production industry to help secure the Nation's clean energy future, reduce the U.S. vulnerability to material shortages related to national defense, and to maintain our global technical and economic competitiveness. Given that the Chinese dominance of the rare earths market has adversely impacted supply stability and endangers the United States and its allies' assured access to key materials, rare earths should qualify as materials either strategic or critical to national security. Further, the U.S. government should facilitate the reintroduction of a globally competitive rare earth industry in the U.S."

It is important to emphasize the *globally competitive* phrase, because the U.S. industries must be economically viable in the global economy. For some mineral commodities, the U.S. may not have sufficient resources that are of high enough grade or large enough to be competitive in today's market. S.383 (Sec. 3) and S.1113 (Sec. 107 and 109) emphasize analyzing U.S. known and undiscovered, potential supplies in context with global supplies. The policy section (Sec. 6) of S.383 appropriately uses the term *economically sound* in its emphasis on domestic supplies: "promote and encourage private enterprise in the development of economically sound and stable domestic critical minerals and materials supply chains."

Section 303 (Authorization of Appropriations) of S.1113 authorizes levels that are, in my opinion, too low for the tasks assigned in Sections 103 (Resource Assessment), 106 (R&D), and 107 (Analysis and Forecasting). Sections 103 and 107 fall within the charge of the USGS's Mineral Resources Program. Given the number of chemical elements that are likely to be considered critical, including those identified in the ECE report, the USGS's Mineral Resources Program would probably need at least twice the amount of funding allocated for Section 103 ($40 million rather than $20 million). In addition, the funding for R&D seems low by a factor of five ($7.5 million per year rather than $1.5 million per year for the five-year period). These issues could be addressed by reprogramming resources within the USGS and DOE.

Thank you, again, for this opportunity to comment on the importance of your work in addressing the national issues regarding critical minerals.

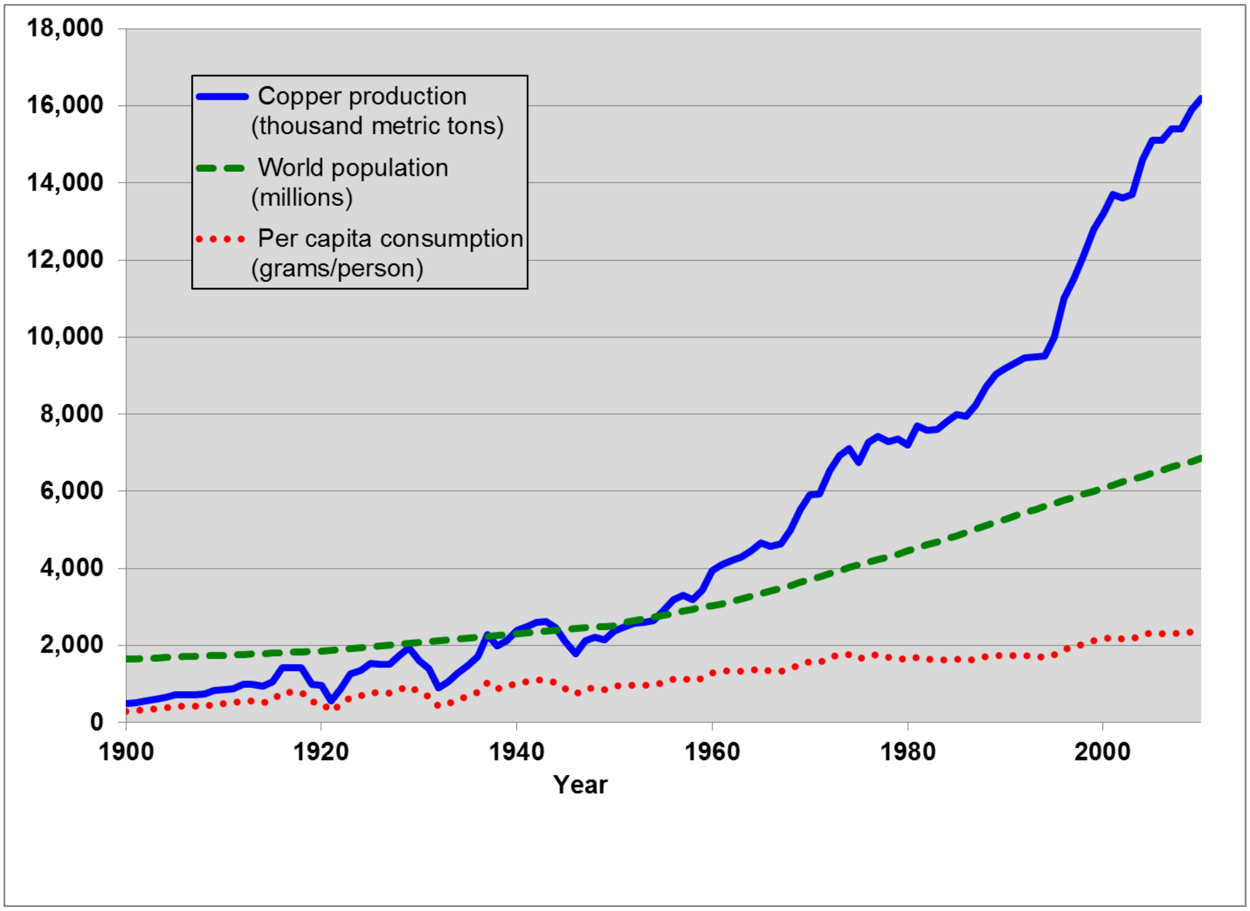

Figure 1. Global production of copper compared with world population and per capita consumption (production divided by population), a measure of average standard of living, from 1900 to 2010 (mineral production data from USGS). Demand for nearly every mineral and energy commodity is high, in part because of increasing world population and in part because of increasing standards of living in many parts of the world. While world population increased four-fold from 1900 to 2010, per capita copper consumption increased eight-fold, such that annual copper production in 2010 was 33 times more than in 1900. Global copper production in 2010 was a record high, at 16.2 million metric tons, approximately the same as the cumulative historical production, since 1906, from the Bingham Canyon copper mine in Utah. Copper is used primarily to conduct electricity.

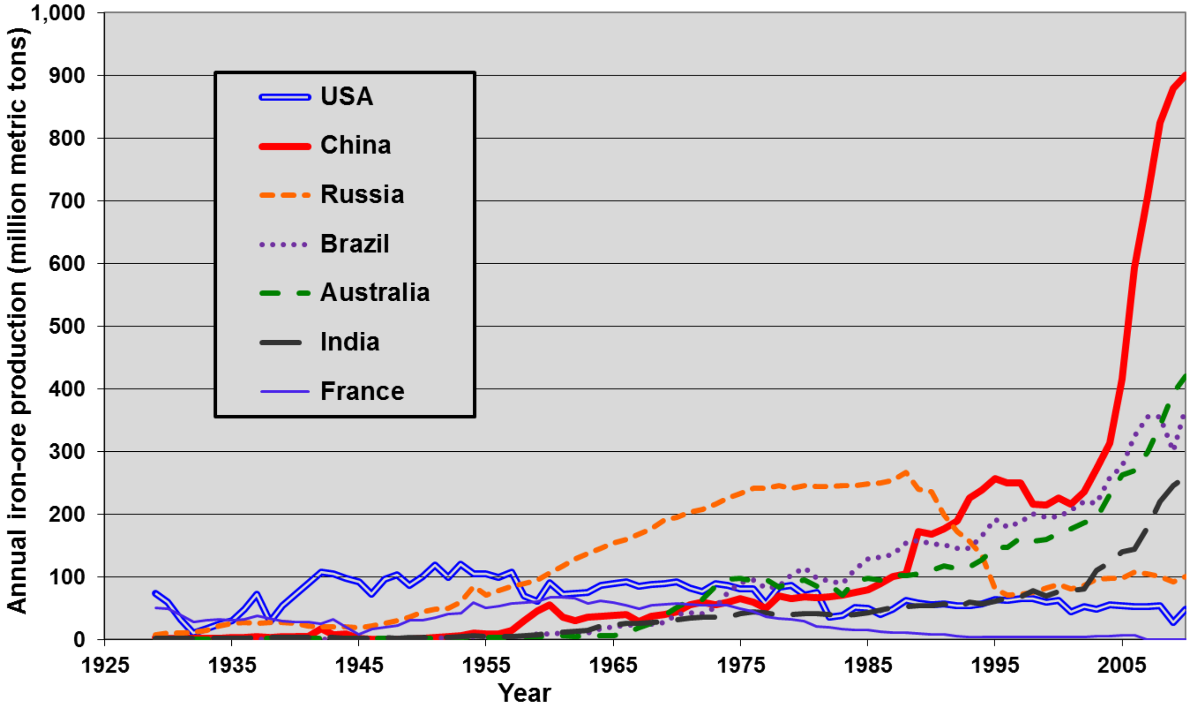

Figure 2. Iron-ore production by country (in millions of metric tons) from 1929 to 2010 (data from USGS). Global annual iron-ore production also reached an all-time high in 2010. Iron is used primarily in steel. Most of the iron-ore production from Australia and Brazil has fed the steel industry in China.

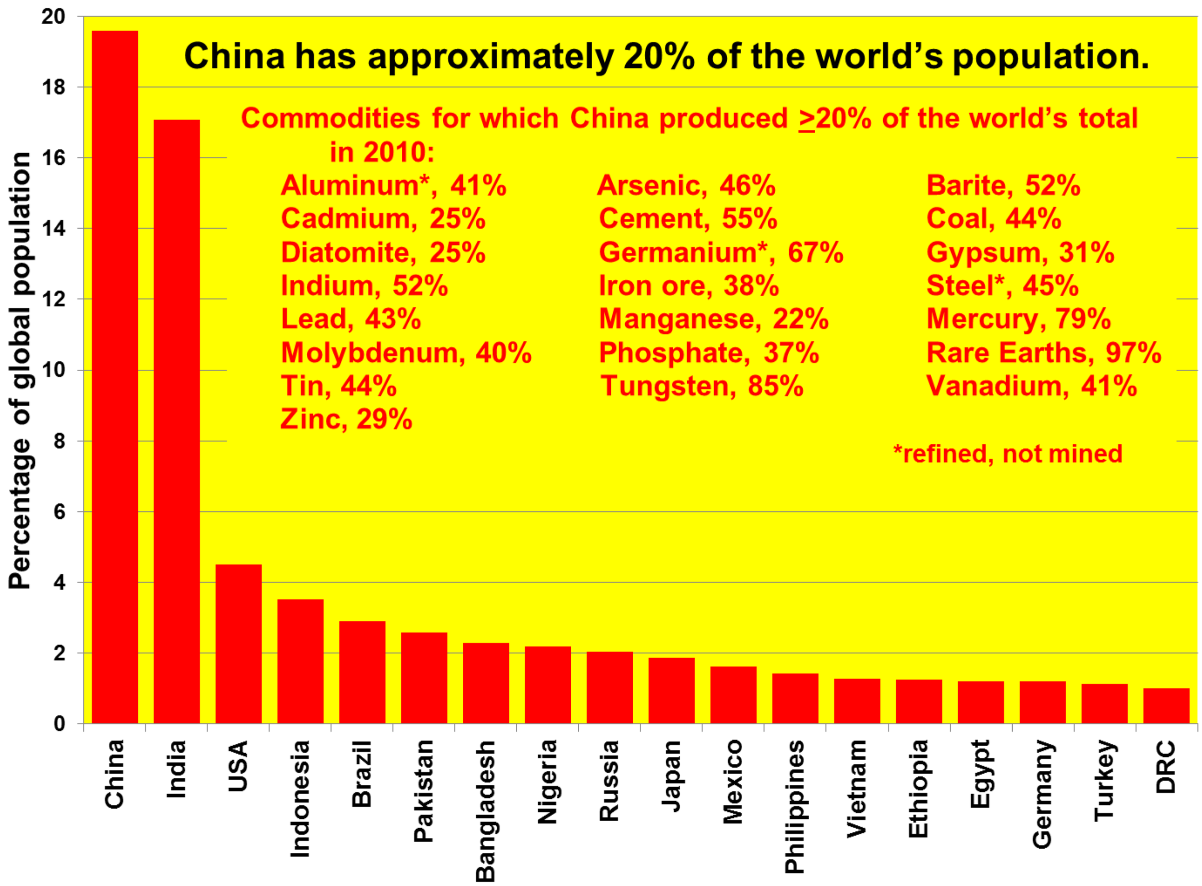

Figure 3. Percentage of global population by country. With approximately 20% of the world's population, China produces well over 20% of the world's supply of many mineral and energy commodities, some of which are highlighted on this graph (population data from CIA, coal production data from EIA, other mineral commodity data from USGS; DRC = Democratic Republic of Congo).

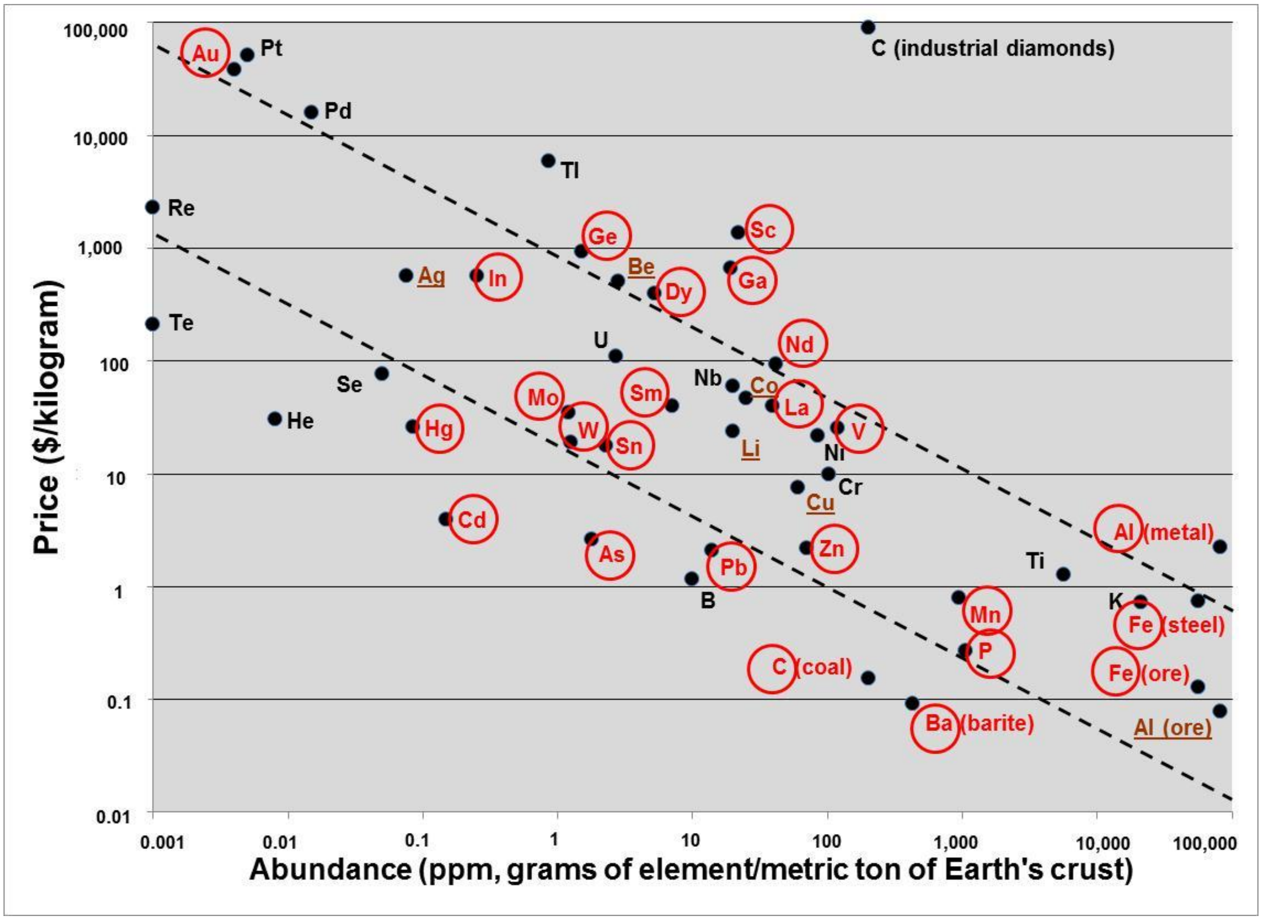

Figure 4. Average price in 2010 versus abundance of various chemical elements (data are mostly from USGS *Mineral Commodity Summaries 2011* for prices and from the 85th edition of the *CRC Handbook of Chemistry and Physics* for abundances). The dashed lines illustrate the general trend of increasing price for rarer elements. In 2010, China was the leading producer of 25 (circled) of the 46 mineral commodities plotted and among the top three producers of another five (underlined). These include silver (Ag), aluminum (Al) metal and ore, arsenic (As), gold (Au), barium (Ba), beryllium (Be), cadmium (Cd), carbon (C, as coal), cobalt (Co), copper (Cu), iron (Fe) as both ore and steel, gallium (Ga), germanium (Ge), mercury (Hg), indium (In), lithium (Li), manganese (Mn), molybdenum (Mo), phosphorus (P), lead (Pb), scandium (Sc), tin (Sn), vanadium (V), tungsten (W), zinc (Zn), and the rare earth elements, with dysprosium (Dy), lanthanum (La), neodymium (Nd), and samarium (Sm) shown on this graph. The United States was the top producer of two, beryllium (Be) and helium (He), and among the top three producing countries for 13 commodities. Russia was the top producer of three, industrial diamonds (another form of carbon, C), nickel (Ni), and palladium (Pd), and among the top three for 12. Australia was the top producer of two, aluminum (Al) ore and titanium (Ti), and among the top three for 10 mineral commodities. Other global leaders include Chile for copper (Cu), lithium (Li), and rhenium (Re); South Africa for chromium (Cr) and platinum (Pt); Democratic Republic of Congo for cobalt (Co); Mexico for silver (Ag); Turkey for boron (B); Brazil for niobium (Nb); Canada for potassium (K); Kazakhstan for uranium (U); and Japan, from its smelting of imported copper ores, for selenium (Se) and Tellurium (Te). Thallium (Tl) is a byproduct of copper, zinc, and lead processing.