Minerals, Biodiversity, and Choices

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Do you remember 1960? In the United States, John F. Kennedy was elected President, the song "Cathy's Clown" by the Everly Brothers headed the top-ten list, and a gallon of gasoline cost 25 cents. The population of the Earth was 3 billion people. Now, 40 years later, the world population is 6 billion people. As the population increases, so does the consumption of most metals, a trend that has continued since the Industrial Revolution. The year 1960 also was the height of the Cold War, a time of concern about shortages of strategic mineral resources, and the early days of the environmental movement. Today, there is no cold war, we have a steady global supply of resources, there is no concern about shortages (at least in the near term), and there are heightened concerns about the environment and sustainable development. Growing materials use, increasing population, and rising living standards are renewing discussions of global priorities and confronting us with difficult choices. How do we assure that we can obtain necessary nonrenewable resources, while minimizing the impact on the environment?

In the current global economy, there generally is an adequate supply of most metals. Nevertheless, we need to maintain a balance that will sustain both the global economy and the global environment. Sometimes, the choice of where to develop comes with the negative consequences of infrastructure development and habitat fragmentation and the subsequent impacts on population, fauna, and flora. A global mineral resource assessment that provides a measure of the distribution and amount of both known and undiscovered mineral resources can assist in making livable choices regarding minerals development and environmental protection. For example, comparison of the distribution of specific mineral resources, both known and undiscovered, with measures of biodiversity can help identify areas where minerals exploitation could most affect ecosystem health. The Washington, D.C.-based nonprofit organization Conservation International (CI) has identified biodiversity hotspots. These areas contain an inordinately large concentration of endemic species and are at the greatest risk for habitat loss. CI recently identified the 25 highest priority hotspots that together contain as endemics 44 percent of the total plant species and 35 percent of all known species of birds, mammals, reptiles, and amphibians. Importantly, the undisturbed part of the hotspot habitat is only 1.4 percent of the Earth's land surface. These hotspots are defined and documented in the book "Hotspots—Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions" (Mittermeier and others, 1999) and in a cover article in "Nature" (Myers and others, 2000). A simplified version of the hotspot-areas map (Conservation International, 2000) is shown in figure 1.

A challenge for society is to recognize and deal with overlaps that will occur between the distribution of ecological hotspots and needed mineral resources. To illustrate both sides of this issue, we consider two elements important to the global economy, but with contrasting sources: tin and chromium. Much of the commodity information used in this paper is from a series of reports by the International Strategic Minerals Inventory group published in U.S. Geological Survey (USGS) Circular 930 (DeYoung and others, 1984; Sutphin and others, 1990) and from annual USGS mineral summaries such as "Mineral Commodity Summaries 2000" (U.S. Geological Survey, 2000).

Chromium

The principal use of chromium is for the production of stainless steel and superalloys. There is no adequate substitute for it. Chromite is the only mineral mined for chromium, and it occurs in a variety of geologic settings. In 1999, the United States net import reliance on chromium was 80 percent (Papp, 2000), with the remainder of U.S. consumption supplied by recycling. India, Kazakhstan, South Africa, and Turkey produce 80 percent of the world production of chromite ore. South Africa provides over 40 percent of the world production. Brazil and Cuba currently are the only producers in the Western Hemisphere (Papp, 2000). Figure 2 shows the global distribution and relative sizes of known chromium sources. Comparing these data to the locations of biodiversity hotspots in the same figure indicates that there is little spatial overlap. Deposits that are present in Madagascar, the Philippines, Cuba, Greece, and Turkey are small and not likely to see major development. No large chromium deposits are known in the 25 biodiversity hotspots, and thus decisions as to where to mine chromite may be based primarily on other factors, such as economics, politics, and local infrastructure issues.

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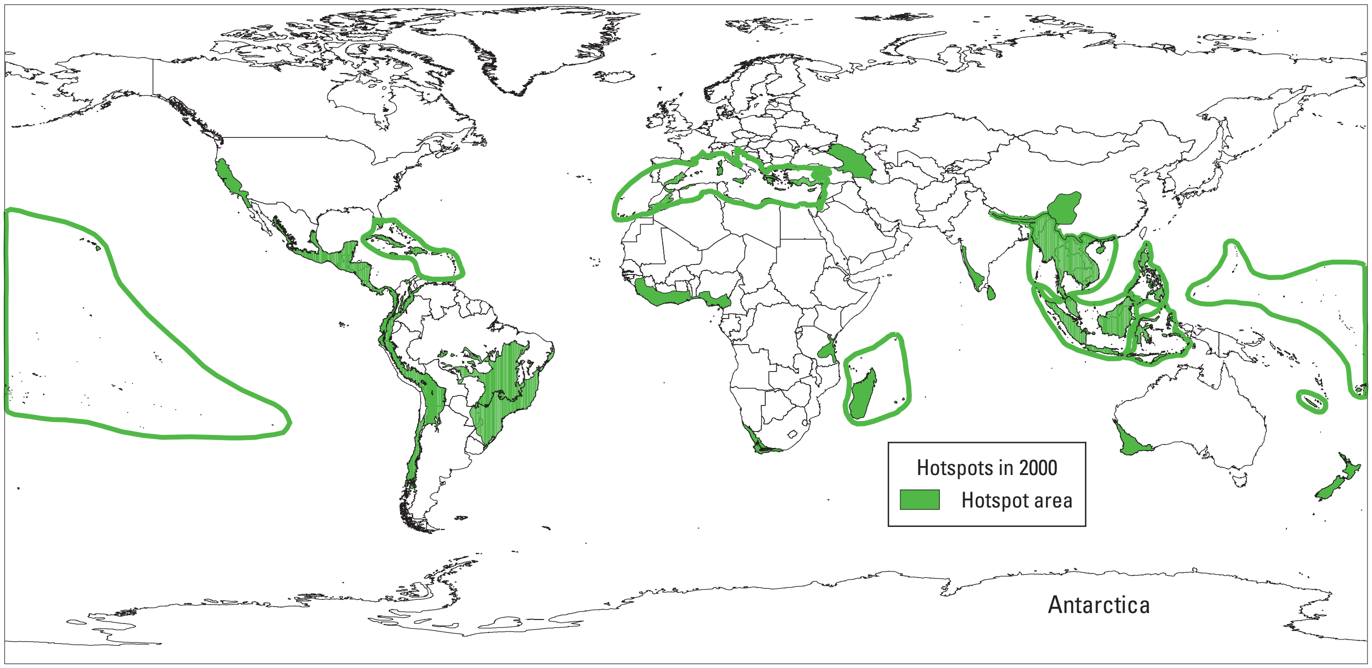

Figure 1. Map of biodiversity hotspots. Modified from Conservation International (2000); used with permission.

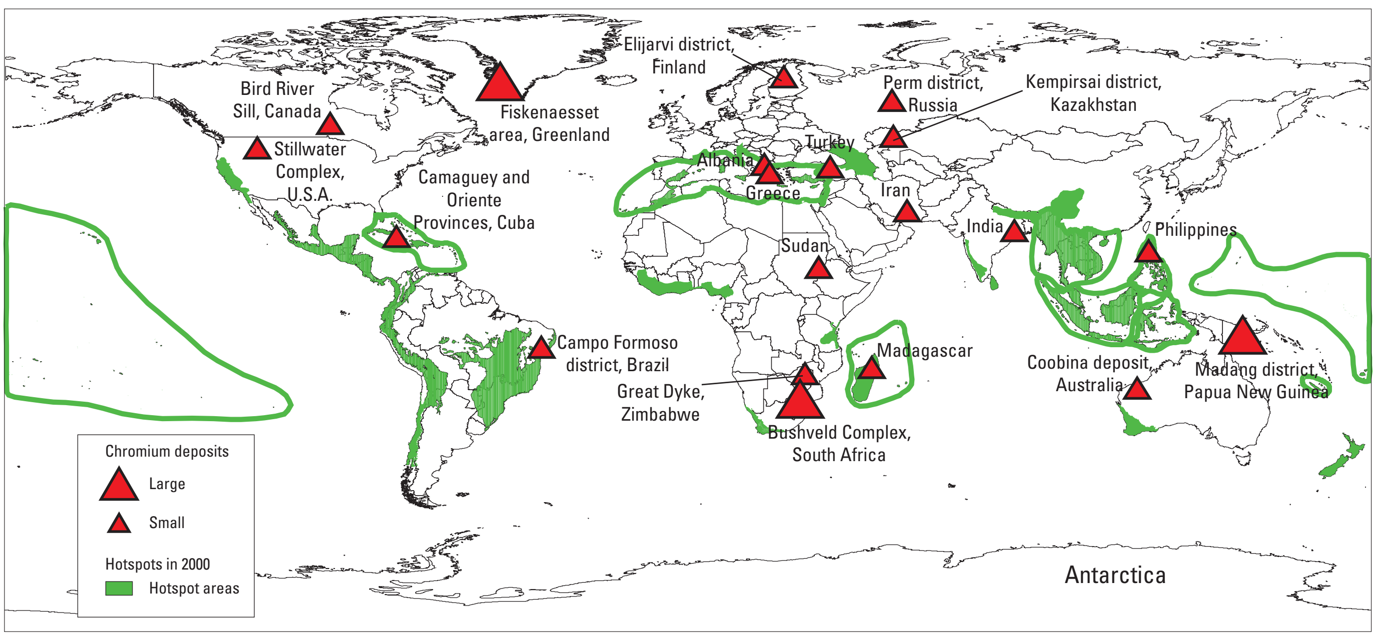

Figure 2. Chromium sources plotted on a map of biodiversity hotspots. Base map modified from Conservation International (2000); used with permission. Chromium deposits primarily modified from DeYoung and others (1984).

Tin

Tin is used extensively for solder in the modern electronics industry, for plumbing in the building trades, and for chemical products. It also is used for cans and containers because of its compatibility with human physiology. Tin is generally nontoxic, is corrosion resistant, and eventually is biodegradable. Although the beverage industry dominates the container market and uses aluminum cans, about a quarter of all cans are tin-plated steel. World consumption of tin is about 250,000 metric tons per annum. The United States uses 40,000 metric tons per annum of tin, more than any other country, with about a quarter of it from recycling.

Tin resources are abundant. The world mines over 200,000 metric tons per annum and makes up the difference between this and total consumption from recycling and stockpiles. Major tin

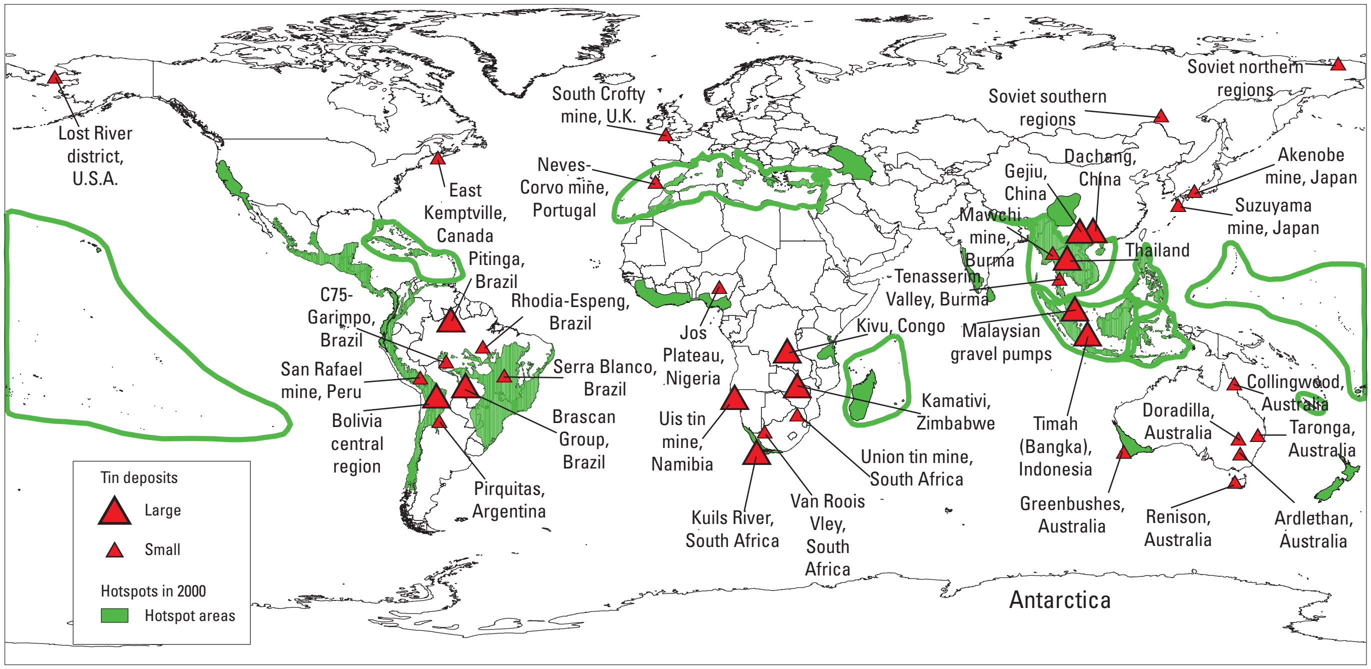

Figure 3. Tin sources plotted on a map of biodiversity hotspots. Base map modified from Conservation International (2000); used with permission. Tin deposits primarily modified from Sutphin and others (1990).

producers are China, Indonesia, Peru, Brazil, and Bolivia (fig. 3; Carlin, 2000). The United States has a Government stockpile of 80,000 metric tons, from which it sells 12,000 metric tons per annum. The United States currently has no need to mine the metal. In fact, industrial market economy countries consume about three-quarters of the world's tin produced each year, while low- and middle-income economy countries account for 90 percent of the world's tin production.

Mineral deposits occur nonuniformly across the Earth's surface, where for geologic reasons, they tend to form in clusters. Almost all tin production has been from similar mineral deposits within specific areas (fig. 3). Therefore, it is reasonable to expect that more production in the future, and many of the new discoveries, will be from these same areas. The juxtaposition of tin sources with the biodiversity hotspots is shown in figure 3. Many of the world's largest tin deposits and known resources occur within the biodiversity hotspots. There is no a priori geologic or biologic reason that there should be such a correspondence in space between known tin deposits and biodiversity hotspots, but the coincidence is striking.

A smaller number of tin deposits, such as those in eastern Australia, Zimbabwe, and Japan, are well away from designated hotspots. Other tin deposits, such as those in Cornwall, U.K., and Alaska, U.S.A., presently are not economic. However, the tin deposits of Indonesia, Thailand, and China are the largest in the world and are within or adjacent to the second richest hotspot for endemic plants. This hotspot also is well known for its mammal diversity and includes the habitat of two recently discovered species—the saola, one of the world's rarest mammals, and the giant muntjac. Some major tin sources in Brazil, such as Pitinga in the western Amazon region, are in the largest tropical rain forest in the world. Smaller deposits to the east are within the hotspot where several unique mammal species occur, including the giant anteater and the maned wolf. The Greenbushes tin deposit in southwestern Australia is within a hotspot rich in endemic plants, reptiles, and marsupial mammals. The large tin deposits of South Africa are in a hotspot noted for having the greatest concentration of nontropical plant species in the world.

Some of the greatest impacts of mining can come from the ancillary effects of infrastructure development, and the effects have both positive and negative aspects. Habitat fragmentation, such as new roads associated with development, farms developed as a result of improved access, or denuded forests that supply fuel and lumber to the developing mining industry, has a major negative effect on biodiversity. On the other hand, mining can also bring jobs to a region, which increases the standard of living and improves medical care, sanitation, transportation, and communication.

Conclusion

In a global economy, environmental concerns will exert a growing influence on the complex choices that must be made with regard to exploration and exploitation of metallic, and nonmetallic, nonrenewable resources. Wise stewardship of our global resources should rely upon informed decisions related to alternative sources, recycling, and alternative substitutions. The bottom line is that a global assessment of mineral resources will help all countries better understand the regional and global implications of decisions they make regarding minerals development and other land uses.

Acknowledgments

Data on biodiversity hotspots were provided by Conservation International. The U.S. Geological Survey gratefully acknowledges the participation of Conservation International in the 2000 IUGS/UNESCO Workshop on Deposit Modeling, Mineral Resource Assessment, and Their Role in Sustainable Development. Paul Barton, Lief Horwitz, and Art Schultz of the U.S. Geological Survey and Penny Flick Langhammer of Conservation International contributed helpful reviews.

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