

Using U.S. Geological Survey Data in Material Flow Analysis

An Introduction

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A few sources of basic data on worldwide raw materials production and consumption exist that are independently developed and freely available to the public. This column is an introduction to the types of information available from the U.S. Geological Survey (USGS), and explains how the data are assembled. The kind of information prepared by the USGS is essential to U.S. materials

flow studies because the data make it possible to conduct these studies within a global context. The data include primary and secondary (scrap) production, consumption and stocks (mostly limited to the United States unless calculated), trade (not readily available for all countries), and prices for more than 80 mineral commodities. Materials flow studies by USGS specialists using these data are continuing (<http://minerals.usgs.gov/minerals/mflow/>). Figure 1 shows from where the data are collected and where they are used. Minerals information was downloaded by users 5.8 million times from USGS minerals information Web pages in 2008.

In the U.S. Federal Government, agencies that regularly use that data are the Department of Defense, the Department of Commerce, the Department of State, the International Trade Commission, the Federal Reserve Board, and the Environmental Protection Agency.

Almost since its founding in 1879, the USGS has been collecting and publishing data on minerals. The U.S. Congress created the agency within the Department of the Interior to provide the United States with knowledge about mineral resources and progress in their development, including a Mining Statistics Division created to collect and disseminate information about the United States'

mineral production and resources. An annual publication, *Mineral Resources of the United States*, which later became the *Minerals Yearbook*, was established.

The core mission of the minerals information activity within the USGS is to collect, analyze, and disseminate information on the domestic and international supply of and demand for minerals and materials essential to the U.S. economy and national security. The USGS has statutory authority for the collection of this information.

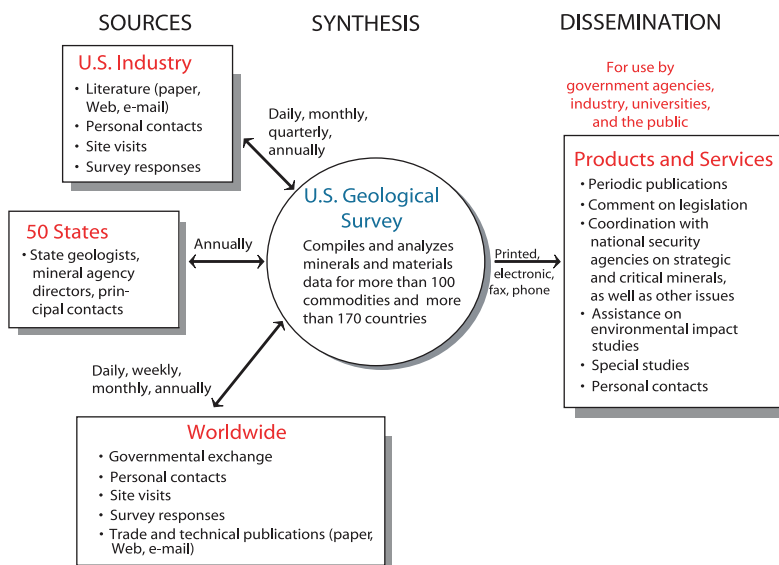
Domestically, the USGS sends out more than 140 canvass forms to more than 18,000 establishments monthly and annually to collect data for analysis and dissemination.

For researchers using USGS data for material flow analysis (MFA), an understanding of how the data are developed and their accuracy is important, particularly for any policy or decision maker using studies based on these data. To enable users to better understand the basis of USGS

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THE FLOW OF MINERALS INFORMATION

Figure 1 The sources of minerals information collected by the USGS and its uses by diverse organizations and institutions.

statistics, each mineral commodity chapter in the USGS *Minerals Yearbook* (2007) includes a section about domestic data coverage. This section briefly describes the data sources, the number of establishments surveyed, the response percentage, and the method of estimating the production or consumption for nonrespondents. When efforts to obtain a response to a survey fail, estimation or imputation techniques must be used to account for missing data. Some of the estimation methods depend on knowledge of prior establishment reporting; other techniques rely on external information to estimate the missing data. When survey forms are received by the USGS after the current publication has been completed, the forms are reviewed, necessary imputations are made for missing data, and the survey database is updated. The revised data based on late forms are reported in the later publication.

The current U.S. Government policy is that all agencies must conduct their business by using the International System of Units (SI), that is, metric units. Each publication figure, whether it is a separate data cell, subtotal, or grand total, is independently converted from the unrounded data to the appropriate publication units and then rounded to the required number of significant

digits. Most of the data published by the USGS are rounded to two or three significant figures, reflecting the inherent uncertainty in the data, even if reported. Data must be imputed for establishments that do not respond. Conversion of data to other than metric units sometimes results in misinterpretation of the data. When a user of USGS-published data converts a figure, care must be taken not only to use the right conversion factor, but also to retain the same number of or fewer significant digits in the rounded product to ensure that the basic data used in materials flow and other studies are presented as accurately as possible so correct conclusions can be drawn. A few examples of use of the data are comparison of supply with demand, determining import dependency, and calculating stocks in use and old scrap generated. USGS data are used by a diverse set of organizations. In the U.S. Federal Government, agencies that regularly use that data are the Department of Defense, the Department of Commerce, the Department of State, the International Trade Commission, the Federal Reserve Board, and the Environmental Protection Agency. Outside the Government, producers, including mining companies and recyclers, as well as investment banks and consultants, use

data on consumption to help determine likely markets for the products to be produced and quantities and locations of metals already being produced elsewhere, and consumers use the data to determine if raw material supply is likely to be sufficient for expected demand for a product, helping to guide their research. Academic institutions not only use the data for instruction, but for special studies and research projects on mineral economics and materials flow, such as those now being conducted at Yale University.

Critical to any material flow analysis are data on stocks throughout the flow cycle. Broadly interpreted, stocks encompass stocks in-ground, or resources, which include reserves and reserve base. Other types of stocks to consider are stocks in use, hibernating stocks (those not in use but not yet recycled, such as material in abandoned buildings), industrial stocks (producer and consumer), government stocks, and trader stocks.

A comprehensive materials flow study would take into account geologic in-ground stocks, referred to in general as resources. Those resources, when accurately measured and evaluated as economical to recover, essentially are reserves. Detailed definitions of the meaning of resources, reserves, and reserve base are reported in Mineral Commodity Summaries [MCS] 2009 (U.S. Geological Survey 2009); reserve and reserve base data in the MCS are rounded to no more than two significant digits. By definition, the figure for the reserve base exceeds the figure for reserves because reserves are defined as a subset of the reserve base. The USGS collects information about the quantity and quality of mineral resources but does not directly measure reserves, and companies or governments do not directly report reserves or reserve base to the USGS. Reassessment of reserves and reserve base is a continuing process, and the intensity of this process differs for mineral commodities, countries, and time periods. National reserves and reserve base information for most mineral commodities found in the USGS *Mineral Commodity Summaries* 2009, including those for the United States, are derived from a variety of sources. National reserves and reserve base (or its equivalent) estimates compiled by countries for selected mineral commodities are a primary source of national reserves and reserve base

information. Important considerations in using reserve and reserve base information are as follows: reserves and reserve base change with price, though listed figures may not change; companies often do not prove reserves beyond a limited period of time for technical or economic reasons, usually up to about 20 years but sometimes considerably less; as reserves are depleted, exploration continues to replenish those reserves; and expansion and development of reserves of mineral commodities that are mainly by-products are dependent on demand for the principal product. Therefore, calculations of “years of supply remaining at current consumption levels” can be very misleading.

Stocks in use are either measured by determining the numbers of products in which they are being used (referred to report-based or the “bottom-up” approach) or are calculated by subtracting material output from input (referred to as apparent stocks in use or the “top-down” approach). For special USGS studies, apparent stocks in use have been calculated (Sullivan 2005). For U.S. industrial (producer and consumer) stocks, the USGS data are usually report-based. For domestic consumption, detailed USGS published monthly data are report-based, whereas total annual data are both report-based and apparent (U.S. Geological Survey 2009).

Production data, both mine and plant (refinery or smelter), are an integral part of materials flow work. Researchers can find the most detailed USGS data in the *Minerals Yearbook* (2007, U.S. Geological Survey, in review). Other considerations in such studies are the use of correct and consistent units of measure, whether figures are for metal content or gross weight, and rounding. These data are often rounded to no more than three significant digits, but data reported by countries are sometimes published unrounded as reported. Another consideration is the type of data used. Sometimes, shipments are used as a substitute for mine production rather than metal content at the mine head. Content of concentrate may also be used for mine production. On a worldwide basis, total production, which is relatively well known, may be used as a substitute for world consumption, with the caveat that some material is lost in processing, and stocks changes usually are not available.

Consumption data are more often imputed than production data because there are many more consumers than producers, and response rates typically are not as good or data are not available from alternative sources, such as company annual reports. Consumption data usually are reported for intermediate processors, such as steel, chemical, or magnet manufacturers, because it would be much more difficult to obtain data from the multitude of finished product manufacturers. Generally, consumption data are only published for the United States, but it is possible to calculate apparent consumption for foreign countries by use of import and export data and production in the country, assuming stock changes are minimal, which is not always the case.

USGS flow studies for recycling metal commodities in the United States have been done on 21 mineral commodities. The last published was on nickel (Goonan 2009). Comprehensive materials flow studies have been conducted on six mineral commodities, the latest being sulfur (Ober 2002). These analyses and investigations would not be possible without the minerals information collected and published by the USGS. The minerals information activity continues to be supported through funding received under the Mineral Resources Program of the USGS. Supplementary information for this article may be found at the *Journal's* Web site.

References

- Goonan, T. G. 2009. Nickel recycling in the United States in 2004. Chapter Z in *Flow studies for recycling metal commodities in the United States*, edited by S. F. Sibley. Reston, VA: U.S. Geological Survey Circular 1196, pp. Z1–Z30.
- Ober, J. A. 2002. *The materials flow of sulfur in the United States*. Reston, VA: U.S. Geological Survey Open File Report 02-298.
- U.S. Geological Survey. 2009. Appendix—A resource/reserve classification for minerals. In *Mineral commodity summaries 2009*. Reston, VA: U.S. Geological Survey.
- U.S. Geological Survey [in review]. Metals and minerals: U.S. Geological Survey *Minerals Yearbook 2007*: v. I, completed chapters available online. <http://minerals.usgs.gov/minerals>. Accessed 28 August 2009.
- Sullivan, D. E. 2005. Metal stocks in use in the United States: U.S. Geological Survey Fact Sheet 2005-3090. <http://pubs.usgs.gov/fs/2005/3090/2005-3090.pdf>. Accessed 28 August 2009.

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Supplementary Material

Additional Supplementary Material may be found in the online version of this article:

Supplement S1. This supplementary material contains suggestions for further reading on the role of government regarding minerals information as well as a figure relating minerals production to gross domestic product not referred to in the main article.

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