U.S. DEPARTMENT OF THE INTERIOR
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DATABASE OF SIGNIFICANT DEPOSITS OF GOLD, SILVER, COPPER, LEAD, AND ZINC IN THE UNITED STATES

PART A: DATABASE DESCRIPTION AND ANALYSIS

by

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CONTENTS

FIGURES

TABLES

INTRODUCTION

It has long been recognized that the largest mineral deposits contain most of the known mineral endowment (Singer and DeYoung, 1980). Sometimes called giant or world-class deposits, these largest deposits account for a very large share of historic and current mineral production and resources in industrial society (Singer, 1995). For example, Singer (1995) shows that the largest 10 percent of the world's gold deposits contain 86 percent of the gold discovered to date.

Many mineral resource issues and investigations are more easily addressed if limited to the relatively small number of deposits that contain most of the known mineral resources. An estimate of known resources using just these deposits would normally be sufficient, because considering smaller deposits would not add significantly to the total estimate. Land-use planning should treat mainly with these deposits due to their relative scarcity, the large share of known resources they contain, and the fact that economies of scale allow minerals to be produced much more cheaply from larger deposits. Investigation of environmental and other hazards that result from mining operations can be limited to these largest deposits because they account for most of past and current production.

The National Mineral Resource Assessment project of the U.S. Geological Survey (USGS) has compiled a database on the largest known deposits of gold, silver, copper, lead, and zinc in the United States to complement the 1996 national assessment of undiscovered deposits of these same metals (Ludington and Cox, 1996). The deposits in this database account for approximately 99 percent of domestic production of these metals and probably a similar share of identified resources. These data may be compared with results of the assessment of undiscovered resources to characterize the nation's total mineral endowment for these metals. This database is a starting point for any national or regional mineral-resource or mineral-environmental investigation.

The Mineral Resource Data System (MRDS) and the Minerals Availability System/Minerals Information Locator System (MAS/MILS) compiled respectively by the USGS and U.S. Bureau of Mines (USBM), and now being merged, contain information on more than 100,000 domestic mines, prospects, and mineral occurrences. The total number of records in the significant deposits database is but 1,118, of which 923 have produced. Limiting a mineral-resource investigation to the deposits in this database will significantly reduce the cost and complexity of such investigations.

This database supersedes the known deposits table in the original release of the national assessment of undiscovered deposits of gold, silver, copper, lead, and Ludington and Cox, 1996). The original database has been extensively revised with hundreds of new records added, greatly improved production and resource data, and some new fields added. All production and resource data were brought up to date as of December 31, 1996.

SIGNIFICANT DEPOSITS DATABASE

This database was first proposed as a summary and analysis of identified resources[1] of gold, silver, copper, lead, and zinc to compare with estimates of undiscovered resources of the same metals made by the 1996 national mineral-resource assessment. To simplify this effort, data on identified resources was to be compiled for only those deposits that collectively account for 99 percent of the domestic resource. Singer, 1995, showed that 99 percent of world resources of these metals occur in deposits that contain more than 2 metric tons gold, 85 metric tons silver, 50,000 metric tons copper, 30,000 metric tons lead, or 50,000 metric tons zinc (table 1). All domestic deposits known to have originally contained more than the threshold value for any of these metals were included in the database.

[1] See Appendix III for definitions of resource terms.

METAL	UNITS	MINIMUM SIZE
Gold	metric t	2
Silver	metric t	85
Copper	10^3 metric t	50
Lead	10^3 metric t	35
Zinc	10^3 metric t	50

Table 1. Criteria for classification of deposits as significant deposits. Minimum sizes are from Singer (1995) who found that deposits of these sizes or larger account for 99 percent of known world resources of these metals.

Data were originally collected by the regional teams responsible for the 1996 national mineral-resource assessment. When the regional databases were combined into a single national database, numerous inconsistencies and data gaps were found. The database subsequently underwent several rounds of editing and updating. John H. DeYoung, Jr., and Stephen D. Ludington edited and updated the database using MRDS, MAS/MILS, and other data sources. Keith R. Long extensively revised and expanded the database based on a more thorough literature search, public filings of mining companies, archival and other sources. Each of the State geological surveys or their equivalents was given the opportunity to review and comment on entries for their States.

Each record is intended to give data on an individual deposit. The consistent application of any definition of a deposit is difficult across the many deposit types represented in the database. In many cases, data on individual deposits is unavailable; in which case, records usually give data for an entire district or some other aggregation of deposits. As a result, the database is really a mixture of records for deposits and districts, which must be taken into account in using or analyzing the data. Hereafter, all records will be referred to as deposits.

Database Description

The database (Long and others, 1998) consists of two portions, an Excel 4.0 spreadsheet file (SD4.XLS) that contains the data, and a Word 6.0 file (SDREF.DOC) that contains the references cited in the spreadsheet. The spreadsheet is divided into several fields that give the name, location, deposit type, discovery date, past production, and remaining resources for each deposit in the database. A detailed description of each field is provided in Appendix 1 and explanatory comments are attached as notes in the spreadsheet to the headers for each field or column.

Data are organized by State, starting with Alaska and ending with Wyoming, and listed alphabetically by deposit name within each State. Deposits are also located by mining district, county, and latitude-longitude. District names and definitions follow those used by the USBM for reporting domestic mineral production as amended by State geological surveys.

Deposit-type classification follows that of Cox and Singer, 1986, as modified by additional models published elsewhere. Appendix 2 provides a complete listing of deposit types used with references to published descriptive models. Mineral-environmental model classification follows that of duBray (1995).

Discovery date is defined as the year in which some part of the deposit was first recognized by persons not indigenous to North America. Many deposits were known to Native Americans who exploited some on a very large scale for copper, turquoise, and pigments. Unfortunately, the history of Native American discovery and utilization of these deposits is obscure, partly because subsequent mineral development has destroyed much of the archaeological evidence. Note that many years can elapse between initial recognition of a deposit and its exploration and development as a mine. Some deposits may never be mined because they occur in or near areas where mining is prohibited.

Production is stated in terms of metals recovered from material mined. Generally, between 40 and 97 percent of the metal originally contained in the ores was recovered, depending on the extractive processes used and the quality of labor and management. Production dates are for the data given. If significant production occurred before or after those dates, a note to that effect is given in the Comments field. Significant production of mineral commodities other than gold, silver, copper, lead, and zinc are indicated under Other Production.

Resources (see Appendix III for definitions of resource terms) are stated in terms of metals contained in remaining material. This material includes that remaining in place as well as stockpiles of previously mined material. Resources given are the sum of all available estimates of remaining reserves and resources at a deposit. For some deposits, only estimates of proven and probable reserves are available, for others, estimates of the total geologic resource are given. No attempt has been made to differentiate between such estimates in the data; all are classified as resources. Resource year is the year in which the resource estimate was calculated or first announced. Significant resources of mineral commodities other than gold, silver, copper, lead, and zinc are indicated under Other Resources.

Sources of data are cited separately for production and resource data. Complete references appear in the companion Word 6.0 file. Some data sources, such as Securities and Exchange Commission Form 10Ks and USBM/USGS Minerals Yearbooks, are cited in a non-standard, abbreviated fashion. These are explained at the end of the companion Word 6.0 file.

Future Plans

The USGS National Mineral Resource Assessment project will continue to maintain and update this database. Eventually, these data will become records in MRDS or its successor with special “Significant Deposit” tags or descriptors. The project also intends to expand the database to other commodities. Users are encouraged to report errors and omissions.

ANALYSIS

The significant deposits database can answer many questions about the Nation’s known resources of gold, silver, copper, lead, and zinc. When were these significant deposits found? Are significant deposits still being found today? Which deposits were the largest producers of these metals? Which deposits have the largest remaining resources? How are these deposits distributed by State or deposit-type? Answering these questions illustrates how the data can be used.

Testing the Database

According to the criteria used to assemble this database, these significant deposits should comprise 99 percent of identified domestic resources, including past production. Table 2 compares the total production of gold, silver, copper, lead, and zinc for deposits in the database with statistics of total production of these metals in the United States. Statistics on the production of recoverable metals from domestically mined ores are only available from 1907. Metal production reported prior to 1907 includes metal recovered from imported ores and excludes metal contained in exported ores. Much of the early metal production data, particularly for gold and silver, are estimates. Production data for zinc prior to 1890 are incomplete.

Complete data on production of gold and silver could not be found for many of the deposits in the database. Many mines had substantial production during the period from 1850 to 1900 when few statistics on individual mine production were collected. During this time national production statistics were derived from data on bullion receipts at Federal mints and individual smelter production. Some likely significant deposits that produced only during that period, including many of the placer deposits mined in California before the 1860s, can not be identified for lack of proper records. Despite these insufficiencies in the data, recorded production of deposits in the database account for 90 and 91 percent respectively of total gold and silver production in the United States.

METAL	UNITS	YEARS FOR WHICH DATA ARE AVAILABLE	TOTAL DOMESTIC MINE PRODUCTION	PRODUCTION OF SIGNIFICANT DEPOSITS	PERCENT OF TOTAL DOMESTIC MINE PRODUCTION
Gold	metric t	1792-1996	13,300	12,000	90
Silver	metric t	1792-1996	185,000	168,000	91
Copper	10^3 metric t	1845-1996	91,100	91,300	100
Lead	10^3 metric t	1720-1996	42,500	41,300	97
Zinc	10^3 metric t	1873-1996	44,100	44,400	101

Table 2. Comparison of total production of gold, silver, copper, lead, and zinc for all deposits in the significant deposits database with statistics on total U.S production of those metals. U.S. production data were compiled from annual volumes of Mineral Resources of the United States (1883 to 1931) and Minerals Yearbooks (1932 to 1996). Data are metals recovered from domestically mined ores from 1907 and metals recovered by domestic smelters and refineries prior to 1907. Data for zinc are incomplete from 1873 to 1890.

Recorded production for copper, lead, and zinc for deposits in the database account for 100, 97, and 101 percent respectively of domestic mine production of these metals. Statistics on total domestic mine production of these metals are incomplete or estimated for the years prior to 1890, particularly for zinc. The apparent excess of copper and zinc production attributed to the deposits in the database can probably be explained by the lack of adjustments for imports and exports of ore and other insufficiencies in the early statistical data.

Table 3 presents current estimates of domestic reserves, reserve base, and resources of gold, silver, copper, lead, and zinc by the USGS and USBM. These estimates were prepared independently from this database by other workers, sometimes from proprietary data not available for this study. Total resources computed from the database are most nearly comparable with the estimates for domestic resources in table 3. For many deposits in the database, however, only data on reserves or the reserve base (reserves plus marginal or subeconomic resources) are available. Hence, total resource figures computed from the database should fall between reported estimates for the domestic reserve base and domestic resources. This is the case for all the metals except gold, where a much larger resource figure is obtained from the database.

		Total Domestic (other studies)			Significant Deposits Database
Metal	Units	Reserves	Reserve Base	Identified Resources	Identified Resources
Gold	metric t	5,600	6,000	9,000	15,000
Silver	metric t	31,000	72,000	190,000	157,000
Copper	10^3 metric t	45,000	90,000	312,000	260,000
Lead	10^3 metric t	7,000	18,000	N/A	51,000
Zinc	10^3 metric t	19,000	60,000	120,000	55,000

Table 3. Comparison of total resources of gold, silver, copper, lead, and zinc remaining in deposits in the significant deposits database with independent estimates of domestic reserves, reserve base, and resources of these metals. Sources of data: U.S. Geological Survey, 1998b (reserve and reserve base for all metals; identified resources for gold); Brobst and Pratt, 1973 (identified resources for silver, copper, and zinc).

Discovery History

Although the exact discovery year for every deposit in the database is not known, they can be specified on a decade or similar basis. In table 4, deposits are grouped by ten time periods corresponding to significant events in the exploration and development of the Nation's mineral resources. For each period, the number of deposits discovered, and their production plus remaining resources are given. Note that adding production and resources for each metal is an imperfect measure of the original size of those deposits due to unaccounted metallurgical losses.

Period	Years	Number Deposits	Gold metric t	Silver metric t	Copper 10^3 metric t	Lead 10^3 metric t	Zinc 10^3 metric t	Discoveries per Year
I	1545-1847	46	300	4,300	27,000	12,000	23,000	0.15
II	1848-1857	133	2,800	1,100	2,000	100	350	15
III	1858-1865	157	3,100	39,800	35,000	4,500	4,300	22
IV	1866-1892	283	7,400	157,000	77,000	15,800	20,500	11
V	1893-1913	177	3,000	44,100	52,000	450	4,400	9
VI	1914-1933	33	250	5,900	2,000	110	480	2
VII	1934-1941	19	1,100	600	1,400	38	86	2
VIII	1942-1945	3	60	500	8,300	4	0	1
IX	1946-1972	104	3,900	43,500	129,000	55,900	32,000	4
X	1973-1996	160	5,100	27,700	17,200	3,400	14,600	7

Table 4. History of the discovery of significant deposits of gold, silver, copper, lead, and zinc in the United States, 1545-1996. Period boundaries correspond to significant events in the development of the U.S. minerals industry.

Period I spans the time between initial European settlement in North America and the California Gold Rush. Deposits discovered in this period are mostly in the eastern part of the United States. Period II corresponds to the California Gold Rush years from 1848 to 1857. Deposits discovered in this period are mostly placer gold and low-sulfide gold-quartz veins in California. Period III covers the discovery of gold in Colorado and silver in Nevada just prior to and during the Civil War. Period IV begins with the first Federal mining law in 1866, which provided a secure legal framework for the exploration and development of mineral properties in the West, and ends with the collapse of silver prices in 1892. During this time, the remaining western States were thoroughly prospected and the first prospecting began in Alaska.

Period V covers the shift from silver to gold exploration after the collapse of silver prices in 1892, aided by the introduction of the cyanide process for recovering gold from refractory ores. During this time significant gold discoveries were made in Nevada and elsewhere. Period VI begins with World War I, when war-related labor shortages and post-war oversupply of metals curtailed mineral exploration and development. The number of deposits discovered in this period dropped dramatically relative to previous periods. Period VII covers most of the Great Depression years, beginning in 1934 when the price of gold was raised to 35 dollars an ounce. Although the rise in gold price stimulated exploration and production of gold, very few new deposits were discovered. Much exploration was directed towards known but previously uneconomic resources.

Wartime labor-shortages and the need to devote resources to expanding reserves at established mines curtailed discoveries to their lowest levels in Period VIII during World War II. The decline in discoveries throughout the first half of the twentieth century may not be due solely to economic factors. The exploration technology of the time, searching for surface indications of significant deposits, may have run its course. Period IX, covering the first decades after World War II saw a substantial increase in discoveries coincident with the introduction of several new exploration technologies, including regional geophysical and geochemical survey methods and the geologic models to utilize them. Exploration was reorganized as well funded regional surveys that targeted geophysical and geochemical anomalies that might indicate concealed deposits.

In 1972, the United States demonetized gold and allowed domestic gold prices to rise to their global market level. A major gold boom which defines Period X followed and continues to this day. It is significant that, of known domestic resources of these metals, 33 percent of gold, 22 percent of silver, 42 percent of copper, 39 percent of lead, and 46 percent of zinc are the result of discoveries since World War II.

Largest Producers and Resources

Tables 5, 6, 7, 8, and 9 show the ten largest producers, remaining resources, and deposits of gold, silver, copper, lead, and zinc respectively. These tables document the largest of the significant deposits, those that are truly world class. Some deposits have been aggregated into districts to facilitate comparison with other deposits in the database which are truly mining districts composed of many deposits. The deposits aggregated are those in the Coeur d'Alene district, Idaho; Keweenaw district, Michigan; Butte, Montana; Bingham Canyon, Utah; and the Franklin and Sterling Hill deposits, New Jersey.

Certain mining districts stand out. The Butte district, Montana, is the largest deposit of silver and copper in the United States as well as one of the ten largest deposits of zinc. The Bingham Canyon district in Utah is the second largest deposit of copper, and one of the ten largest gold and silver deposits. Red Dog, Alaska, is the largest zinc, second largest lead, and fourth largest silver deposit.

Among the gold deposits, it is notable that the largest remaining resources mainly occur in sediment-hosted and other bulk-mineable gold deposits discovered in the last thirty years (Goldstrike-Post-Meikle, Twin Creeks, Gold Quarry-Maggie Creek, Pipeline, McDonald, and Jerritt Canyon). Two very low-grade placer gold deposits in Wyoming (Pass Peak, Oregon Gulch) are also among the largest gold deposits. Bingham Canyon, Utah, illustrates the amount of gold to be found in some of the largest porphyry copper deposits.

Butte, Montana, is the largest deposit of silver and copper. Sediment-hosted copper deposits such as Rock Creek and Montanore, Montana, are also very large deposits of silver. Porphyry copper deposits, mainly in Arizona, dominate the list of largest copper deposits, although magmatic Ni-Cu deposits in Minnesota (Partridge River) are also important resources.

Viburnum, Missouri, and Red Dog, Alaska, are the largest lead deposits. Crandon, Wisconsin, is one of the largest deposits of lead and zinc along with other massive sulfide deposits (Lik-Su and Greens Creek, Alaska). The large zinc resource at Butte, Montana, is also noteworthy.

Among the largest producers are several deposits that do not figure as significantly in remaining resources. The Homestake, South Dakota, mine was the largest gold producer. The Hammonton dredge field and Empire-Star mine in California were also among the largest gold producers. Leadville and Aspen, Colorado; Comstock and Tonopah, Nevada; and the Coeur d'Alene district, Idaho were among the largest silver producers.

The Keweenaw copper district was a major source of copper. The Coeur d'Alene district, Idaho, was a major producer of zinc, lead, and silver, but now figures only in the top ten list of resources of silver. Polymetallic replacement deposits at Park City and Tintic-East Tintic, Utah, as well as the Mississippi Valley deposits in the Old Lead Belt of Missouri were among the most important sources of lead. Franklin-Sterling Hill, New Jersey, accounts for 15 percent of all recorded zinc production in the United States.

These ten largest remaining resources of these metals include some deposits widely perceived as worked out (Butte, Montana) and others whose development is controversial (Crandon, Wisconsin; McDonald, Montana). Others, such as Red Dog, Alaska; Bingham Canyon, Utah; and Goldstrike-Post-Miekle, Nevada, are among the largest metal mines in the world. Some deposits are not now considered even remotely economic (Pass Peak and Oregon Gulch, Wyoming).

DEPOSIT	STATE	GOLD PRODUCED metric t
Homestake	SD	1,237
Bingham Canyon district	UT	671
Cripple Creek	CO	605
Goldstrike-Post	NV	307
Comstock	NV	258
Gold Quarry-Maggie Creek	NV	258
Fairbanks	AK	250
Empire-North Star	CA	196
Hammonton	CA	160
Nome	AK	152

DEPOSIT	STATE	GOLD RESOURCE metric t
Goldstrike-Post-Meikle	NV	1,500
Pass Peak	WY	1,400
Oregon Gulch	WY	800
Bingham Canyon district	UT	580
Twin Creeks	NV	560
Gold Quarry-Maggie Creek	NV	380
Pipeline	NV	350
Round Mountain	NV	330
McDonald	MT	260
Jerritt Canyon	NV	240

DEPOSIT	STATE	GOLD PRODUCED PLUS RESOURCE metric t
Goldstrike-Post-Meikle	NV	1,800
Pass Peak	WY	1,400
Homestake	SD	1,400
Bingham Canyon district	UT	1,300
Oregon Gulch	WY	800
Cripple Creek	CO	670
Twin Creeks	NV	670
Gold Quarry-Maggie Creek	NV	640
Round Mountain	NV	470
Jerritt Canyon	NV	380

Table 5. The ten largest domestic gold deposits in terms of past production, remaining resources, and past production plus remaining resources.

Deposit	State	Silver produced metric t
Coeur d'Alene district	ID	29,200
Butte district	MT	22,400
Tintic-East Tintic	UT	8,500
Park City	UT	7,900
Leadville	CO	7,700
Bingham Canyon district	UT	7,500
Comstock	NV	6,000
Tonopah	NV	5,400
Aspen	CO	3,100
Copper Queen	AZ	2,800

Deposit	State	Silver resource metric t
Butte district	MT	22,500
Red Dog	AK	10,800
Rock Creek	MT	9,800
Coeur d'Alene district	ID	9,400
Montanore	MT	9,300
Bingham Canyon district	UT	7,400
Hahns Peak	CO	6,400
Greens Creek	AK	5,400
Hardshell	AZ	3,400
Rochester	NV	3,200

Deposit	State	Silver produced plus resource metric t
Butte district	MT	44,300
Coeur d'Alene district	ID	42,400
Bingham Canyon district	UT	15,700
Red Dog	AK	11,400
Rock Creek	MT	9,800
Tintic-East Tintic	UT	9,400
Montanore	MT	9,300
Leadville	CO	8,900
Park City	UT	8,100
Hahns Peak	CO	6,400

Table 6. The ten largest domestic silver deposits in terms of past production, remaining resources, and past production plus remaining resources.

DEPOSIT	STATE	COPPER PRODUCED 10^3 metric t
Bingham Canyon district	UT	14,200
Butte district	MT	9,800
Morenci-Metcalf	AZ	9,400
Santa Rita	NM	5,000
Keweenaw district	MI	4,900
Ray	AZ	4,600
Inspiration-Miami	AZ	4,500
San Manuel-Kalamazoo	AZ	3,700
Mission-Pima-San Xavier	AZ	3,400
Copper Queen	AZ	3,000

DEPOSIT	STATE	COPPER RESOURCE 10^3 metric t
Butte district	MT	25,200
Lone Star	AZ	24,900
Partridge River (Duluth)	MN	14,600
Morenci-Metcalf	AZ	12,800
Bingham Canyon district	UT	11,800
Dos Pobres	AZ	9,000
Santa Cruz	AZ	8,200
Ray	AZ	6,200
Birch Lake	MN	5,900
Rosemont-Helvetia	AZ	5,200

DEPOSIT	STATE	COPPER PRODUCED PLUS RESOURCE 10^3 metric t
Butte district	MT	35,000
Bingham Canyon district	UT	26,400
Lone Star	AZ	24,900
Morenci-Metcalf	AZ	22,500
Partridge River (Duluth)	MN	14,600
Ray	AZ	10,700
Dos Pobres	AZ	9,000
Santa Rita	NM	8,700
San Manuel-Kalamazoo	AZ	8,300
Santa Cruz	AZ	8,200

Table 7. The ten largest domestic copper deposits in terms of past production, remaining resources, and past production plus remaining resources.

DEPOSIT	STATE	LEAD PRODUCED 10^3 metric t
Viburnum	MO	11,200
Old Lead Belt	MO	7,700
Coeur d'Alene district	ID	7,200
Tri-State	MO OK KS	2,600
Bingham Canyon district	UT	2,000
Park City	UT	1,200
Leadville	CO	1,100
Tintic-East Tintic	UT	1,000
Upper Mississippi Valley	WI IL IA	800
Mine LaMotte-Fredericton	MO	500

DEPOSIT	STATE	LEAD RESOURCE 10^3 metric t
Viburnum	MO	28,500
Red Dog	AK	14,700
Burkesville	KY	1,400
Tintic-East Tintic	UT	700
Lik-Su	AK	680
Hahns Peak	CO	640
Greens Creek	AK	370
Crandon	WI	320
Bingham Canyon district	UT	310
Arctic Camp	AK	290

DEPOSIT	STATE	LEAD PRODUCED PLUS RESOURCE 10^3 metric t
Viburnum	MO	39,700
Red Dog	AK	15,000
Old Lead Belt	MO	7,700
Coeur d'Alene district	ID	7,700
Tri-State	MO OK KS	2,600
Bingham Canyon district	UT	2,300
Tintic-East Tintic	UT	1,800
Leadville	CO	1,400
Burkesville	KY	1,400
Park City	UT	1,300

Table 8. The ten largest domestic lead deposits in terms of past production, remaining resources, and past production plus remaining resources.

DEPOSIT	STATE	ZINC PRODUCED 10^3 metric t
Tri-State	MO OK KS	10,600
Franklin-Sterling Hill	NJ	6,300
Coeur d'Alene district	ID	3,400
Balmat-Edwards-Pierrepoint	NY	2,500
Mascot-Jefferson City	TN	2,400
Butte district	MT	2,200
Red Dog	AK	1,800
Upper Mississippi Valley	WI IL IA	1,500
Austinville-Ivanhoe	VA	1,400
Viburnum	MO	1,400

DEPOSIT	STATE	ZINC RESOURCE 10^3 metric t
Red Dog	AK	22,000
Crandon	WI	3,700
Butte district	MT	2,300
Arctic Camp	AK	2,000
Lik-Su	AK	1,960
Fountain Run	KY	1,800
Burkesville	KY	1,600
Tintic-East Tintic	UT	1,500
Viburnum	MO	1,400
Central Tennessee	TN	1,100

DEPOSIT	STATE	ZINC PRODUCED PLUS RESOURCE 10^3 metric t
Red Dog	AK	23,800
Tri-State	MO OK KS	10,800
Franklin-Sterling Hill	NJ	6,300
Butte district	MT	4,600
Crandon	WI	3,700
Balmat-Edwards-Pierrepoint	NY	2,900
Viburnum	MO	2,860
Mascot-Jefferson City	TN	2,500
Arctic Camp	AK	2,000
Lik-Su	AK	1,960

Table 9. The ten largest domestic zinc deposits in terms of past production, remaining resources, and past production plus remaining resources.

To provide some comparison between deposits of the different metals, metal production and resources have been converted to dollar amounts using rounded average prices (in 1987 dollars) for the last ten to twenty years. Table 10 gives the ten largest deposits in dollar terms. Butte, Montana, colloquially known as the "richest hill on earth" is the largest, followed by Bingham Canyon, Utah, and Lone Star, Arizona.

Deposit	State	Value of metal produced plus resources in billion 1987 dollars
Butte district	MT	162
Bingham Canyon district	UT	128
Lone Star	AZ	45
Morenci-Metcalf	AZ	41
Red Dog	AK	32
Partridge River	MN	27
Viburnum	MO	25
Ray	AZ	20
Goldstrike-Post	NV	18
Dos Pobres	AZ	16

Table 10. The ten largest domestic deposits of gold, silver, copper, lead, and zinc in terms of the gross value of past production plus remaining resources for these metals calculated using average prices for these metals over the last twenty to thirty years. Prices, in 1987 dollars, are $350 per ounce gold, $ 5.00 per ounce silver, $1.00 per pound copper, $0.45 per pound lead, and $0.50 per pound zinc. Price data are from U.S. Bureau of Mines, 1993. Gross value of other metal production and resources (molybdenum, nickel, etc.) excluded.

Distribution by State

Tables 11 and 12, show the total amount of gold, silver, copper, lead, and zinc produced and contained in remaining resources for all significant deposits of these metals in each State. A few States have been combined with adjacent States where significant deposits extend across State boundaries.

Significant deposits in Nevada have produced the most gold and contain the largest remaining gold resource of any State. Deposits in Idaho have produced the most silver, but deposits in Montana have the largest remaining silver resource. Arizona has produced half the nation's copper and has nearly half the remaining copper resource. Lead production and resources are dominated by the Missouri-Oklahoma-Kansas region. Deposits in that region have produced the most zinc but Alaska has the largest remaining zinc resource.

Nevada's prominence in gold production and resources result from the discovery and development of numerous sediment-hosted, hot-spring, and other bulk-mineable gold deposits in the last thirty years. Alaska's large zinc resources are mostly attributable to the Red Dog deposit discovered in 1968. Copper resources in Arizona are largely the result of post-World War II discoveries of new and extensions of known porphyry copper deposits.

	Production from Significant Deposits				
State	Gold metric t	Silver metric t	Copper 10^3 metric t	Lead 10^3 metric t	Zinc 10^3 metric t
Alaska	1,030	2,060	660	363	1,960
Arizona	451	14,050	45,600	581	1,130
California	2,670	3,520	527	159	102
Colorado	1,120	21,100	286	2,570	2,780
Georgia	2				
Idaho	335	35,900	208	7,340	3,520
Illinois (south)-Kentucky		7		64	266
Illinois (north)-Iowa-Wisconsin	9	100	155	779	1,460
Maine		8	13	3	84
Michigan	6	1,500	6,660		
Minnesota					
Missouri-Kansas-Oklahoma		1,710	384	22,600	12,200
Montana	638	29,400	10,000	675	2,440
Nevada	2,810	24,900	2,940	601	415
New Hampshire					
New Jersey					6,260
New Mexico	96	2,680	7,840	245	1,360
New York		61		77	2,490
North Carolina	15	10	67		
Oregon	109	73	8		
Pennsylvania	2	14	260		
South Carolina	55	6			
South Dakota	1,360	396			
Tennessee	1	489	704	16	3,300
Texas		1,053	1	36	
Utah	1,030	27,900	14,900	5,000	1,900
Vermont		16	51		13
Virginia	7			29	1,420
Washington	211	683	97	212	555
Wyoming	13		10		

Table 11. Total amount of gold, silver, copper, lead, and zinc produced from significant deposits in each State with one or more significant deposits. Some States have been combined where significant deposits extend across State borders.

State	Resources in Significant Deposits				
	Gold metric t	Silver metric t	Copper 10^3 metric t	Lead 10^3 metric t	Zinc 10^3 metric t
Alaska	1,290	26,200	11,700	16,600	29,300
Arizona	337	9,460	121,000	43	861
California	1,350	4,410	1,500	54	819
Colorado	273	12,400	254	1,110	1,280
Georgia					
Idaho	362	14,400	1,560	533	922
Illinois (south)-Kentucky				1,360	3,400
Illinois (north)-Iowa-Wisconsin	111	3,630	997	437	4,680
Maine	7	715	813	200	1,160
Michigan	1	1,000	8,680		
Minnesota	>49	>1,210	32,800		
Missouri-Kansas-Oklahoma		1,620	313	28,700	1,640
Montana	1,080	48,200	30,500	73	2,440
Nevada	6,100	13,900	12,800	188	478
New Hampshire	1	25	11	8	36
New Jersey					
New Mexico	149	856	7,210	53	423
New York					436
North Carolina	15				
Oregon	203	199	121		121
Pennsylvania					449
South Carolina	46				
South Dakota	330	>1			
Tennessee				unknown	1,660
Texas		1,560	105		
Utah	647	13,200	14,300	1,150	2,940
Vermont					
Virginia	7	239	1,040	119	1,360
Washington	519	4,040	13,200	381	1,030
Wyoming	2,290	85	1,350		

Table 12. Total amount of gold, silver, copper, lead, and zinc contained as resources in significant deposits in each State with one or more significant deposits. Some States have been combined where significant deposits extend across State borders.

Distribution by Deposit Type

Table 18 gives the total amount of gold, silver, copper, lead, and zinc produced plus that contained in remaining resources for each of the deposit types to which deposits in the database have been assigned. The principal deposit types for each metal, however, are more readily seen in tables 13 through 17.

The most important deposit types for gold production and resources are sediment-hosted gold, placer gold, and epithermal veins. Silver production and resources is more evenly divided among several deposit types. Polymetallic replacement and Coeur d'Alene polymetallic veins are the most important deposit types for silver production, and porphyry copper, sediment-hosted copper, and massive sulfides are most important for silver resources.

Some 72 percent of copper production and 70 percent of copper resources are attributable to porphyry copper deposits. Over half of all lead production and resources are attributable to Mississippi Valley-type deposits. Mississippi Valley-type deposits account for about half of zinc production but sedimentary exhalative Zn-Pb deposits contain nearly half the remaining zinc resource.

	GOLD PRODUCTION	
Deposit Type	metric t	Percent Total
Epithermal vein	2,650	22
Placer Au	2,530	21
Sediment-hosted Au	1,420	12
Low-sulfide Au-quartz vein	1,410	12
Homestake Au	1,250	10
Porphyry Cu	887	7

	GOLD RESOURCES	
Deposit Type	metric t	Percent Total
Sediment-hosted Au	4,080	27
Placer Au	3,040	20
Epithermal vein	2,760	18
Porphyry Cu	998	7
Low-sulfide Au-quartz vein	769	5
Skarn	650	4

Table 13. Principal types of significant gold deposits in terms of production and remaining resources. The epithermal vein deposit type includes the Comstock, Creede, hot-springs, quartz-alunite, and Sado deposit models.

	Silver Production	
Deposit Type	metric t	Percent Total
Polymetallic replacement	43,100	26
Vein, Coeur d'Alene	33,100	20
Vein, polymetallic	31,200	19
Epithermal vein	24,900	15
Porphyry Cu	11,100	7
Distal-disseminated Ag-Au	7,800	5

	Silver Resources	
Deposit Type	metric t	Percent Total
Porphyry Cu	25,800	16
Sediment-hosted Cu	23,600	15
Massive sulfide	19,800	13
Vein, polymetallic	15,400	10
Epithermal vein	12,200	8
Sedimentary exhalative Zn-Pb	12,200	8

Table 14. Principal types of significant silver deposits in terms of production and remaining resources. The epithermal vein deposit type includes the Comstock, Creede, hot-springs, quartz-alunite, and Sado deposit models. Porphyry copper-related polymetallic veins are included in the polymetallic vein deposit type.

	COPPER PRODUCTION	
Deposit Type	10^3 metric t	Percent Total
Porphyry Cu	66,100	72
Vein, polymetallic	7,800	9
Basaltic Cu	4,900	5
Polymetallic replacement	3,700	4
Massive sulfide	3,500	4
Sediment-hosted Cu	2,100	2

	COPPER RESOURCES	
Deposit Type	10^3 metric t	Percent all types
Porphyry Cu	183,300	70
Magmatic Ni-Cu	34,400	13
Skarn	9,100	4
Sediment-hosted Cu	8,600	3
Massive sulfide	6,200	2
Basaltic Cu	3,100	1

Table 15. Principal types of significant copper deposits in terms of production and remaining resources. The magmatic Ni-Cu deposit type includes the Duluth, Stillwater, and synorogenic-synvolcanic deposit models. The skarn deposit type includes the skarn Au, skarn Cu, skarn Fe, and skarn Zn-Pb deposit models. Porphyry copper-related polymetallic veins are included in the polymetallic vein deposit type.

	LEAD PRODUCTION	
Deposit Type	10^3 metric t	Percent Total
Mississippi Valley	23,700	57
Polymetallic replacement	7,300	18
Vein, Coeur d'Alene	7,200	17
Vein, polymetallic	1,900	5
Sedimentary exhalative Zn-Pb	425	1
Massive sulfide	260	1

	LEAD RESOURCES	
Deposit Type	10^3 metric t	Percent Total
Mississippi Valley	30,200	59
Sedimentary exhalative Zn-Pb	15,400	30
Massive sulfide	1,880	4
Polymetallic replacement	1,560	3
Vein, polymetallic	589	1
Vein, Coeur d'Alene	436	1

Table 16. Principal types of significant lead deposits in terms of production and remaining resources. The massive sulfide deposit type includes the Besshi, Cyprus, and Kuroko deposit models. Porphyry copper-related polymetallic veins are included in the polymetallic vein deposit type.

	Zinc Production	
Deposit Type	10^3 metric t	Percent Total
Mississippi Valley	19,800	45
Franklin-Sterling Hill	6,260	14
Polymetallic replacement	5,120	12
Sedimentary exhalative Zn-Pb	4,390	10
Vein, polymetallic	3,750	8
Vein, Coeur d'Alene	3,370	8

	Zinc Resources	
Deposit Type	10^3 metric t	Percent Total
Sedimentary exhalative Zn-Pb	24,600	44
Massive sulfide	13,600	25
Mississippi Valley	7,900	14
Polymetallic replacement	3,070	6
Vein, polymetallic	3,030	5
Skarn	1,890	3

Table 17. Principal types of significant zinc deposits in terms of production and remaining resources. The massive sulfide deposit type includes the Besshi, Cyprus, and Kuroko deposit models. Porphyry copper-related polymetallic veins are included in the polymetallic vein deposit type. The skarn deposit type includes the skarn Au, skarn Cu, skarn Fe, and skarn Zn-Pb deposit models. The Franklin-Sterling zinc deposits may be metamorphosed sedimentary-exhalative deposits.

Deposit Type	Number Deposits	Gold metric t	Silver metric t	Copper 10^3 metric t	Lead 10^3 metric t	Zinc 10^3 metric t
Alkaline Au-Te	25	1,340	623		2	
Basaltic Cu	13			8,030		
Detachment fault-related polymetallic	9	114	88	358	4	
Distal-disseminated Ag-Au	25	664	18,700	4	119	1
Duluth Cu-Ni	8	>49	>1,210	32,900		
Epithermal vein, Comstock	60	1,410	23,700	6	5	2
Epithermal vein, Creede	4	10	3,290	2	165	4
Epithermal vein, quartz-alunite	8	202	132	6		
Epithermal vein, Sado	7	196	2,540	3		
Exotic Cu	2			544		
Franklin-Sterling Hill Zn	2					6,260
Homestake Au	3	1,420	>281			
Hot Spring Au-Ag	51	2,250	6,870		15	1
Kennecott Cu	1		311	544		
Kipushi Cu	3		15	1,830	2	121
Low-sulfide Au-quartz vein	144	2,180	>303	1	18	
Massive sulfide, Besshi	13	4	587	2,260	36	1,140
Massive sulfide, Cyprus	1	14	55	53		121
Massive sulfide, Kuroko	64	540	24,300	7,330	2,100	13,900
Mississippi Valley Pb-Zn	22		3,340	362	53,900	27,700
Olympic Dam Cu-U-Au	1			301		
Placer Au	154	48,000	>5,570			
Placer PGE	1	>1				
Polymetallic replacement	45	643	48,500	5,290	8,770	8,190
Porphyry Au	6	304	>10	13		
Porphyry Cu	102	1,890	36,900	249,000	12	19
Porphyry Mo	8		1,890	7,500		
Replacement/Vein Au-Fe	4	30				
Sedimentary-exhalative Cu-Co	3			429		
Sedimentary-exhalative Zn-Pb	7	5	13,300	274	15,900	29,000
Sediment-hosted Au	67	5,500	>466			
Sediment-hosted Cu	20	4	26,800	10,700		
Skarn Au	17	460	1,230	126	1	
Skarn Cu	10	329	8,280	8,070		511
Skarn Fe	3	2	14	1,460		
Skarn Zn-Pb	7	1	1,350	124	288	1,530
Stillwater Ni-Cu	2			1,290		
Syntectonic-synorogenic Ni-Cu	3		2	325		
Vein, peraluminous Au-Ag	4	20	17			
Vein, Congress-type, polymetallic	3	61	74	1	1	

Deposit Type	Number Deposits	Gold metric t	Silver metric t	Copper 10^3 metric t	Lead 10^3 metric t	Zinc 10^3 metric t
Vein, Coeur d'Alene polymetallic	26	5	42,200	168	7,620	3,760
Vein, Cu	4	28	1,250	1,420	3	46
Vein, polymetallic	96	1,270	19,500	556	1,920	2,080
Vein, polymetallic, porphyry-Cu related	7	92	27,100	9,130	546	4,710
Vein, Sn-Cu	2		168	8		
Tailings	3	40	>250	1	>84	>103
Unclassified	49	487	8,950	638	896	981

Table 18. Total amount of gold, silver, copper, lead, and zinc produced and contained in remaining resources in the various types of significant deposits. The Franklin-Sterling Hill zinc deposits may be metamorphosed sedimentary-exhalative zinc deposits.

Comparison with Estimates of Undiscovered Resources

Table 19 compares identified resources and past production of gold, silver, copper, lead, and zinc from the significant deposits database with mean estimates of undiscovered resources of the same metals from the 1996 National Mineral Resource Assessment (Ludington and Cox, 1996). The estimates of undiscovered resources are for the conterminous United States only, hence known resources and past production for Alaska have been excluded from Table 19 to facilitate comparison.

The 1996 National Mineral Resource Assessment (Ludington and Cox, 1996) estimated probability distributions for the amount of metal in undiscovered deposits to a depth of one kilometer. The means of those distributions, which are the values shown in table 19, are the expected or most likely values for the amount of metal contained in undiscovered deposits.

Estimates of undiscovered gold resources in the conterminous United States are roughly the same as the amount of identified remaining resources. The comparison, however, is not exact as some of the identified resources from the significant deposits database extend below one kilometer depth. For all other metals, estimates of undiscovered resources exceed identified resources, in the cases of silver and zinc, by a factor of three and five respectively. Total resources, identified plus undiscovered, exceed past production by substantial amounts.

Type of Resource	Gold metric t	Silver metric t	Copper 10^3 metric t	Lead 10^3 metric t	Zinc 10^3 metric t
Undiscovered	18,000	460,000	290,000	85,000	210,000
Identified, unmined	15,000	157,000	260,000	51,000	55,000
Past Production	12,000	168,000	91,000	41,000	44,000

Table 19. Comparison of estimates of undiscovered resources in the conterminous United States of gold, silver, copper, lead, and zinc with identified resources and past production of the same metals for deposits in the significant deposits database. Estimates of undiscovered resources are from U.S. Geological Survey, 1998a.

CONCLUSIONS

The U.S. Geological Survey has developed an up-to-date database of significant precious- and base-metal deposits in the United States. This database will be a valuable tool for mineral-resource and mineral-environmental investigations, particularly by limiting the scope of these investigations to those deposits which are most important.

The database of significant domestic resources of gold, silver, copper, lead, and zinc demonstrates several salient features that may not have been readily apparent before. Approximately a third of the Nation's resources have been discovered in the last forty years, including some of the largest known deposits of some metals such as Red Dog, Alaska (zinc, silver); Goldstrike-Post, Twin Creeks, Gold Quarry-Maggie Creek, Round Mountain, and Jerritt Canyon, Nevada (gold); Lone Star and Dos Pobres, Arizona (copper); and Viburnum, Missouri (lead). Some deposits, such as Butte, Montana (silver, copper, zinc), which are now inactive or no longer major producers, contain a very large share of remaining resources. Identified resources of all metals are less than the mean of estimates of undiscovered resources for these metals.

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APPENDIX I. FIELD DEFINITIONS FOR THE SIGNIFICANT DEPOSITS DATABASE

Each column in the spreadsheet is a separate field in the database. Fields are defined below under their respective column headings.

Deposit
Name of the deposit or aggregation of deposits (usually by district). Commonly used synonyms are given in parentheses. Where two or more mines develop the same deposits, mine names are joined by a hyphen to create a deposit name.

District
Name of the mining district to which the deposit belongs. District names follow those used by the U.S. Bureau of Mines for reporting domestic mine production. Where State geological surveys have modified district names or definitions, those modifications have been followed.

County
County or counties where a deposit occurs.

State
State or States in which a deposit occurs.

Lat and Long

Latitude and longitude coordinates for a deposit. For very large deposits, the coordinate represents an approximate central point within the deposit. Accuracy of these coordinates, which come from a wide variety of sources, is not known.

Deposit Type
Name of the U.S. Geological Survey deposit model to which a deposit has been assigned. A few deposits have been assigned model names for which no formal deposit models have yet been developed by the U.S. Geological Survey. See Appendix II for a list of deposit model names with references to published models.

Deposit Type No.
Number of the U.S. Geological Survey deposit model corresponding to the assigned model.

Alternate Deposit Types
Where there is some uncertainty or debate over which model to assign a deposit, an alternate model may also be assigned. See Appendix II for a list of deposit model names with references to published models.

Alternate Deposit Type No.
Number of the alternate U.S. Geological Survey deposit model to which a deposit has been assigned.

Environmental Model
Name of the U.S. Geological Survey geoenvironmental model to which a deposit has been assigned. See Appendix II for a list of deposit model names with references to published models.

Discovery Year
Year in which some part of the deposit was first recognized by persons not indigenous to North America. When the exact year is uncertain, an approximate date is indicated by a tilde (~) placed before the date, or placed within a decade by an expression such as 1860s, or otherwise explained.

Production Dates
Years of production covered by the production data given. If a deposit is known to have produced outside of those dates, a note to that effect is placed in the Comments field.

<u>Production Tonnage</u>

Tonnage of material, in thousands of metric tons, originally mined and processed to recover the metals whose production is given in the other production fields. Reprocessed material, such as tailing and slag, are excluded to avoid double-counting.

<u>Production Au</u>

Metric tons of gold recovered from material mined and processed.

<u>Production Ag</u>

Metric tons of silver recovered from material mined and processed.

<u>Production Cu</u>

Thousands of metric tons of copper recovered from material mined and processed.

<u>Production Pb</u>

Thousands of metric tons of lead recovered from material mined and processed.

<u>Production Zn</u>

Thousands of metric tons of zinc recovered from material mined and processed.

<u>Other Production</u>

A listing of other mineral commodities recovered from mining a deposit.

<u>References: Production</u>

Citation of reference sources for the production data given. Complete references appear in a separate file.

<u>Resource Year</u>

Year a resource estimate for a deposit was published or calculated.

<u>Resource Tonnage</u>

Tonnage of material, in thousands of metric tons, remaining in a deposit that contains the metal resources reported in the other resource fields.

<u>Resource Au</u>

Metric tons of gold contained in the remaining resource.

<u>Resource Ag</u>

Metric tons of silver contained in the remaining resource.

<u>Resource Cu</u>

Thousands of metric tons of copper contained in the remaining resource.

<u>Resource Pb</u>

Thousands of metric tons of lead contained in the remaining resource.

<u>Resource Zn</u>

Thousands of metric tons of zinc contained in the remaining resource.

<u>Other Resources</u>

A listing of other mineral commodities contained in the remaining resource.

<u>References: Resources</u>

Citation of reference sources for the resource data given. Complete references appear in a separate file.

Comments

Explanatory comments for any of the data given in a record.

APPENDIX II. MINERAL DEPOSIT MODELS USED TO CLASSIFY DEPOSITS

DEPOSIT MODEL	MODEL NUMBER	REFERENCES
Alkaline Au-Te	22b	Cox and Singer, 1986
Basaltic Cu	23	Cox and Singer, 1986
Cu-Co, Blackbird-type	24d	Cox and Singer, 1986
Detachment fault-related polymetallic	40a	Long, 1992; Long, 1993
Distal-disseminated Ag-Au	19c	Cox, 1992; Cox and Singer, 1992
Duluth Cu-Ni	5a	Cox and Singer, 1986
Epithermal vein, Comstock	25c	Cox and Singer, 1986
Epithermal vein, Creede	25b	Cox and Singer, 1986
Epithermal vein, quartz-alunite	25e	Cox and Singer, 1986
Epithermal vein, Sado	25d	Cox and Singer, 1986
Exotic Cu		None
Homestake stratiform Au	36b	Cox and Singer, 1986
Hot Spring Au-Ag	25a	Cox and Singer, 1986; Berger and Singer, 1992
Kennecott-type Cu		None
Kipushi Cu	32c	Cox and Singer, 1986
Low-sulfide Au-quartz vein	36a	Cox and Singer, 1986
Massive sulfide, Besshi	24b	Cox and Singer, 1986
Massive sulfide, Cyprus	24a	Cox and Singer, 1986
Massive sulfide, Kuroko	28a	Cox and Singer, 1986
Mississippi Valley, Appalachian Zn	32b	Cox and Singer, 1986
Mississippi Valley, southeast Missouri Pb-Zn	32a	Cox and Singer, 1986
Olympic Dam Cu-U-Au	29b	Cox and Singer, 1986
Placer Au	39a	Cox and Singer, 1986
Placer PGE	39b	Cox and Singer, 1986
Polymetallic replacement	19a	Cox and Singer, 1986
Porphyry Au	20d	Rytuba and Cox, 1991
Porphyry Cu	17	Cox and Singer, 1986
Porphyry Cu, skarn-related	18a	Cox and Singer, 1986
Porphyry Cu-Au	20c	Cox and Singer, 1986
Porphyry Cu-Mo	21a	Cox and Singer, 1986
Porphyry Mo, Climax	16	Cox and Singer, 1986
Porphyry Mo, low-F	21b	Cox and Singer, 1986
Replacement/Vein Au-Fe		None
Sedimentary-exhalative Zn-Pb	31a	Cox and Singer, 1986
Sediment-hosted Au	26a	Cox and Singer, 1986; Mosier and others, 1992
Sediment-hosted Cu	30b	Cox and Singer, 1986
Skarn Au	18f	Theodore and others, 1991
Skarn Cu	18b	Cox and Singer, 1986
Skarn Fe	18d	Cox and Singer, 1986
Skarn Zn-Pb	18c	Cox and Singer, 1986
Stillwater Ni-Cu	1	Cox and Singer, 1986
Strata-bound Zn (Franklin-Sterling Hill)		None
Synorogenic-synvolcanic Ni-Cu	7a	Cox and Singer, 1986
Vein, Au-quartz, peraluminous granite		None

DEPOSIT MODEL	MODEL NUMBER	REFERENCES
Vein, Congress-type, polymetallic		None
Vein, Coeur d'Alene polymetallic		White and Long, in preparation
Vein, Cu		Eckstrand and others, 1995
Vein, polymetallic	22c	Cox and Singer, 1986
Vein, polymetallic, porphyry-Cu related		None
Vein, polymetallic Ag-Sn	20b	Cox and Singer, 1986

Appendix III. A Resource/Reserve Classification for Minerals[1]

Introduction

Through the years, geologists, mining engineers, and others operating in the minerals field have used various terms to describe and classify mineral resources, which as defined herein include energy minerals. Some of these terms have gained wide use and acceptance, although they are not always used with precisely the same meaning.

The U.S. Geological Survey collects information about the quantity and quality of all mineral resources. In 1976, the USGS and the U.S. Bureau of Mines developed a common classification and nomenclature, which was published as U.S. Geological Survey Bulletin 1450-A, *"Principles of the Mineral Resource Classification System of the U.S. Bureau of Mines and U.S. Geological Survey."* Experience with this resource classification system showed that some changes were necessary in order to make it more workable in practice and more useful in long-term planning. Therefore, representatives of the U.S. Geological Survey and the U.S. Bureau of Mines collaborated to revise Bulletin 1450-A. Their work was published in 1980 as U.S. Geological Survey Circular 831, *"Principles of a Resource/Reserve Classification for Minerals."*

Long-term public and commercial planning must be based on the probability of discovering new deposits, on developing economic extraction processes for currently unworkable deposits, and on knowing which resources are immediately available. Thus, resources must be continuously reassessed in the light of new geologic knowledge, of progress in science and technology, and of shifts in economic and political conditions. To best serve these planning needs, identified resources should be classified from two standpoints: (1) purely geologic or physical/chemical characteristics of the material in place, such as grade, quality, tonnage, thickness, and depth; and (2) profitability analyses based on costs of extracting and marketing the material in a given economy at a given time. The former constitutes important objective scientific information of the resource and a relatively unchanging foundation upon which the latter more valuable economic delineation can be based.

The revised classification systems, designed generally for all mineral materials, are shown graphically in figures 1 and 2; their components and usage are described in the text. The classification of mineral and energy resources is necessarily arbitrary, because definitional criteria do not always coincide with natural boundaries. The system can be used to report the status of mineral and energy-fuel resources for the Nation or for specific areas.

Resource/Reserve Definitions

A dictionary definition of resource, "something in reserve or ready if needed," has been adapted for mineral and energy resources to comprise all materials, including those only surmised to exist, that have present to anticipated future value.

Resource. A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Original Resource. The amount of a resource before production.

Identified Resources. Resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. Identified resources include economic, marginally economic, and sub-economic components. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into measured, indicated, and inferred.

Demonstrated. A term for the sum of measured and indicated.

[1] From U.S. Geological Survey 1988 Mineral Commodity Summaries based on U.S. Geological Survey Circular 831, 1980

Measured. Quantity is computed from dimensions revealed in outcrops, trenches, working, or drill holes; grade and quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that the size, shape, depth, and mineral content of the resource are well established.

Indicated. Quantity, grade, and quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume continuity between points of observation.

Inferred. Estimates are based on an assumed continuity beyond measured and indicated resources, for which there is geologic evidence. Inferred resources may or may not be supported by samples or measurements.

Reserve Base. That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. The reserve base is the in-place demonstrated (measured plus indicated) resource from which reserves are estimated. It may encompass those parts of the resources that have reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The reserve base includes those resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those that are currently subeconomic (subeconomic resources). The term “geologic reserve” has been applied by others generally to the reserve-base category, but it may also include the inferred-reserve-base category. It is not a part of this classification system.

Inferred Reserve Base. The in-place part of an identified resource from which inferred reserves are estimated. Quantitative estimates are based largely on knowledge of the geologic character of a deposit for which there may be no samples or measurements. The estimates are based on an assumed continuity beyond the reserve base, for which there is geologic evidence.

Reserves. That part of the reserve base which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as “extractable reserves” and “recoverable reserves” are redundant and are not part of this classification system.

Marginal Reserves. That part of the reserve base which, at the time of determination, borders on being economically producible. Its essential characteristic is economic uncertainty. Included are resources that would be producible, given postulated changes in economic or technological factors.

Economic. This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

Subeconomic Resources. The part of identified resources that does not meet the economic criteria of reserves and marginal reserves.

Undiscovered Resources. Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. Undiscovered resources may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or subeconomic. To reflect varying degrees of geologic certainty, undiscovered resources may be divided into two parts.

Hypothetical Resources. Undiscovered resources that are similar to known mineral bodies and that may be reasonably expected to exist in the same producing district or region under analogous geologic conditions. If exploration confirms their existence and reveals enough information about their quality, grade, and quantity, they will be reclassified as identified resources.

Speculative Resources. Undiscovered resources that may occur either in known types of deposits in favorable geologic settings where mineral discoveries have not been made, or in types of deposits as yet unrecognized for their economic potential. If exploration confirms their existence and reveals enough information about their quantity, grade, and quality, they will be reclassified as identified resources.

Restricted Resources/Reserves. That part of any reserve/resource category that is restricted from extraction by law or regulations.

Other Occurrences. Materials that are too low grade or for other reasons are not considered potentially economic may be recognized and their magnitude estimated, but they are not classified as resources.

Cumulative Production. The amount of past cumulative production is not, by definition, a part of a resource. Nevertheless, a knowledge of what has been produced is important to an understanding of current resources, in terms of the amount of past production and the amount of remaining in-place resource. Material left in the ground during current or future extraction should be recorded in the resource category appropriate to its economic-recovery potential.

Figure 1. Major elements of mineral-resource classification, excluding *Reserve Base* and *Inferred Reserve Base*.

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUBECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		
Other Occurrences	Includes unconventional and low-grade materials				

Figure 2. *Reserve Base* and *Inferred Reserve Base* classification categories.

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserve Base		Inferred Reserve Base		
MARGINALLY ECONOMIC					
SUBECONOMIC					
Other Occurrences	Includes unconventional and low-grade materials				

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CMH	Canadian Mines Handbook, Southam Business Communications Inc., Don Mills, Ontario, Canada (annual).
CMJ	Canadian Mining Journal
E/MJ	Engineering and Mining Journal, Maclean Hunter Publishing Co., Chicago, IL (monthly).

ME	Mining Engineering, Society for Mining, Metallurgy, and Exploration, Littleton, CO (monthly).
MJ	Mining Journal, Mining Journal Ltd., London, England (weekly).
MM	Mining Magazine, Mining Journal Ltd., London, England (monthly).
MMN	Major Mines of Nevada, Nevada Bureau of Mines and Geology, Special Publication (annual).
MR	Mining Record, Howell Publishing Co., Denver, CO (weekly).
NM	The Northern Miner, Southam Magazine Group, Don Mills, Ontario, Canada (weekly).
NMI	The Nevada Mineral Industry, Reno, Nevada Bureau of Mines and Geology, Special Publication, MI series (annual).
PCIA	Primary Copper Industry of Arizona, Phoenix, Arizona Department of Mines and Mineral Resources, Special Report (annual).
PD	Pay Dirt, Copper Queen Publishing Co., Bisbee, AZ (monthly).
Randol	Randol mining directory, Randol International Ltd., Golden, CO (biannual).
SEGN	Society of Economic Geologists Newsletter, Littleton, CO (quarterly)
SK	Skillings' Mining Review, Skillings' Mining Review Inc., Duluth, MN (weekly).

SEC Form 10K: Annual reports filed by domestic public companies with the Securities and Exchange Commission (SEC) in compliance with the 1934 Securities Exchange Act and Title 17, Code of Federal Regulations, Parts 200 to end. Reports filed with the SEC are available for public inspection at the SEC Library, New York City. Microfiche copies are available at many university libraries or may be purchased from Disclosure, Inc. The SEC's EDGAR database of electronic copies of filings made since 1994 is accessible via the internet at www.sec.gov.

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