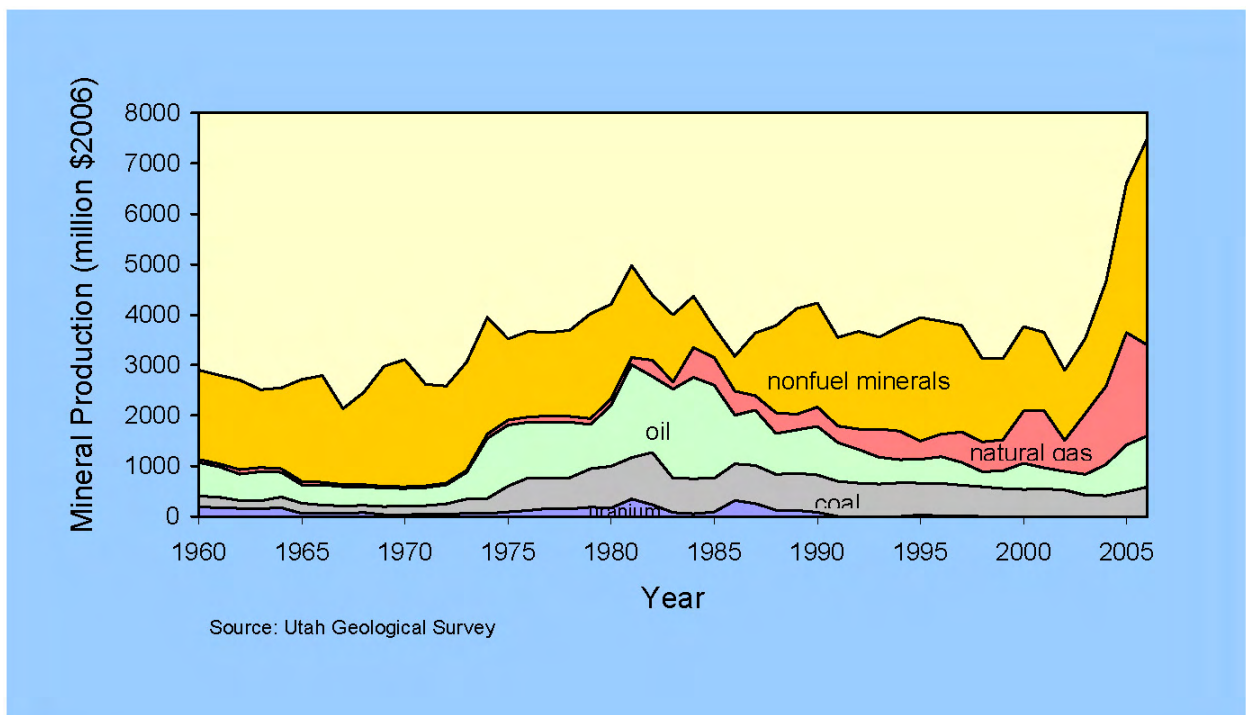


## 2006 Summary of Mineral Activity in Utah

R.L. Bon and K.A. Krahulec, Utah Geological Survey

### SUMMARY

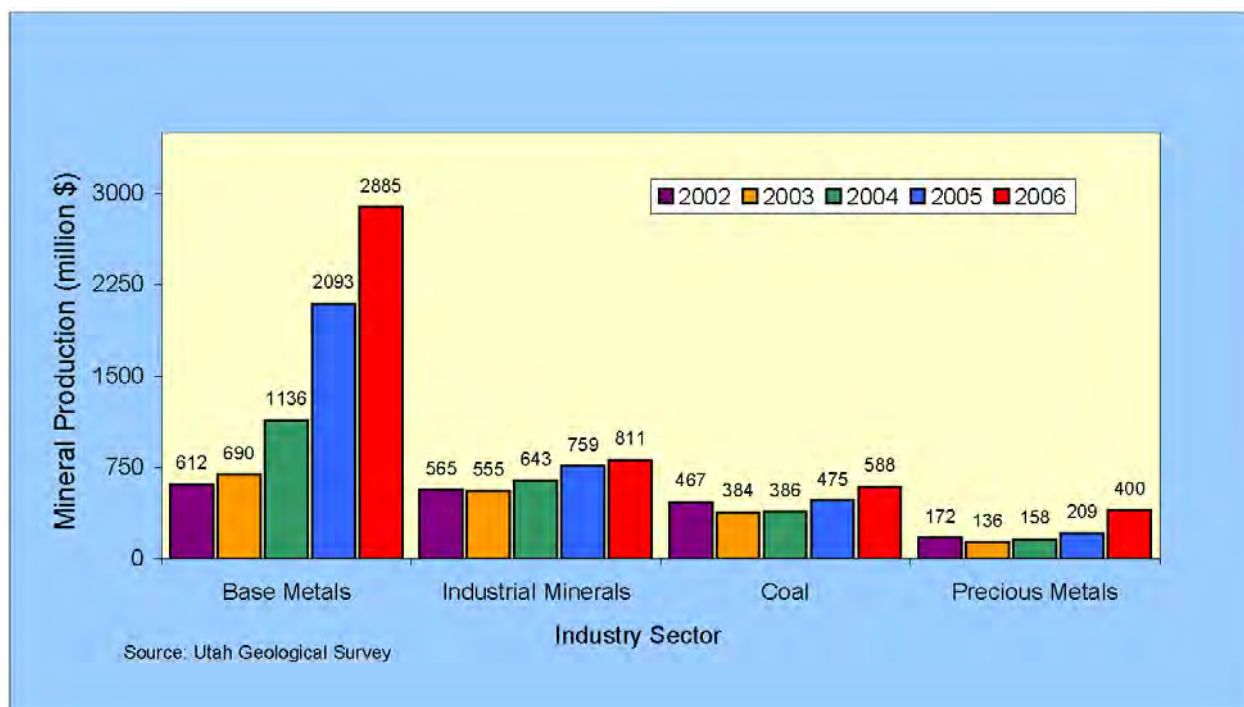
The gross value of all energy and mineral commodities produced in Utah in 2006 has continued the strong upward trend that began in 2003. The gross annual revenue is now about \$7.6 billion, greatly exceeding even the inflation-adjusted revenue from any previous year (figure 1). The previous peak of \$4.9 billion in 1981 was largely due to a sharp rise in the price of oil. The 2006 escalation in value is largely due to both high prices and increased production in base metals, precious metals, oil, and coal.



**Figure 1. Total annual value of Utah's mineral production, inflation adjusted to 2006 U.S. dollars.**

The value of Utah's mineral production (including coal) in 2006 is estimated at a record \$4.68 billion (figure 2), \$1.15 billion (33%) higher than the revised value of \$3.53 billion for 2005. All major mineral industry segments gained in value in 2006 for the fourth year in a row. Contributions from each of the segments were as follows: base metals, \$2.88 billion (62% of total); industrial minerals, \$811 million (17% of total); coal, \$588 million (13% of total); and precious metals, \$400 million (8% of total) (figure 2; table 1). Compared to 2005, the 2006 values of (1) base metals increased \$792 million (38%), (2) industrial minerals increased \$52 million (7%), (3) coal increased \$113 million (24%), and (4) precious metals increased \$191 million (92%).

Preliminary estimates from the U.S. Geological Survey (USGS) rank Utah 4<sup>th</sup> nationally in the value of nonfuel minerals produced in 2006, and Utah accounted for about 6.2% of the



**Figure 2. Value of Utah's annual mineral production shown in millions of dollars, by sector, from 2002 through 2006.**

total U.S. nonfuel mineral production value (Tanner, 2007). Based on Energy Information Administration data, Utah ranked 15<sup>th</sup> in coal production in 2005 (Energy Information Administration, 2006), and will likely remain in the same position for 2006.

Metal prices reached historic highs in 2006, climbing from the record lows reached in 2001-02. The increase in metal prices has led to substantially increased mineral exploration and development in Utah. In addition to the initiation of mining at the Lisbon Valley copper mine and the Pandora uranium mine, both in San Juan County, advanced stage exploration and development is ongoing in the Iron Springs (Fe) and Rocky Range-Beaver Lake (Cu-Au) mining districts.

Mineral exploration statewide increased in 2006. During 2006, the Utah Division of Oil, Gas and Mining (DOGM) received five Large Mine permit applications (2 ha [5 acres] and larger disturbance) and 41 new Small Mine permit applications (less than 2 ha [5 acres] disturbance). Thirty-five Notices of Intent to explore on public lands were filed with DOGM in 2006, compared to 27 in 2005 and 14 in 2004. Over 6000 new federal unpatented mining claims were recorded in Utah in 2006. The Utah School and Institutional Trust Lands Administration generated record revenues in fiscal year 2006.

Utah was rated as the fourth-best governmental body for mining operations as reported in the 2006/2007 Fraser Institute Survey of Mining Company's Policy Potential Index. The Fraser survey rates the favorability of the political environment in 14 U.S. states, 12 Canadian provinces and territories, and 39 countries.

The outlook for 2007 is for a moderate decline in the value of nonfuel mineral production based largely on projections for lower production of base and precious metals coupled with lower base-metal prices. Most base- and precious-metal prices increased significantly from 2003 through 2006 and, while prices should remain relatively high overall, some lowering of base-

metal prices is anticipated, while precious metal prices are projected to remain strong. Industrial-mineral prices should remain near their current levels as Utah's economic recovery continues, although a reduction in demand for several commodities is projected. Coal prices and production are projected to increase as new coal contracts are being negotiated at significantly higher prices and demand for coal continues to increase.

## NATIONAL RANKINGS

The USGS's 2006 preliminary data ranks Utah 4<sup>th</sup> in the nation in the value of nonfuel mineral production, the same as in 2005. USGS data show that Utah accounted for 6.2% of the total U.S. nonfuel mineral production value, compared to 5.6% in 2005 (Tanner, 2007). For 2006, USGS data show that Utah remained the only state that produced beryllium concentrates and magnesium metal. Additionally, Utah was 2<sup>nd</sup> in the quantity of copper, molybdenum concentrates, gold, potash, and magnesium compounds produced (in descending order of value); 4<sup>th</sup> in phosphate rock and silver; and 5<sup>th</sup> in salt. The state was also a significant producer of Portland cement, construction sand and gravel, lime, common clays, and gemstones (Tanner, 2007).

The USGS's preliminary estimate of the value of nonfuel mineral production for 2006 is \$3.99 billion (Tanner, 2007), about \$1.2 billion (43%) higher than in 2005. USGS data show that between 2002 and 2006 the value of nonfuel mineral production in Utah increased from \$1.24 billion (a 10-year low) in 2002 to a record high \$3.99 billion in 2006 (figure 3). The Utah Geological Survey's (UGS) estimate for the value of nonfuel mineral production for 2006 is \$4.23 billion, compared to \$3.06 billion for 2005.

A summary of estimated mineral values by the UGS from 1997 through 2006 is shown in table 1.

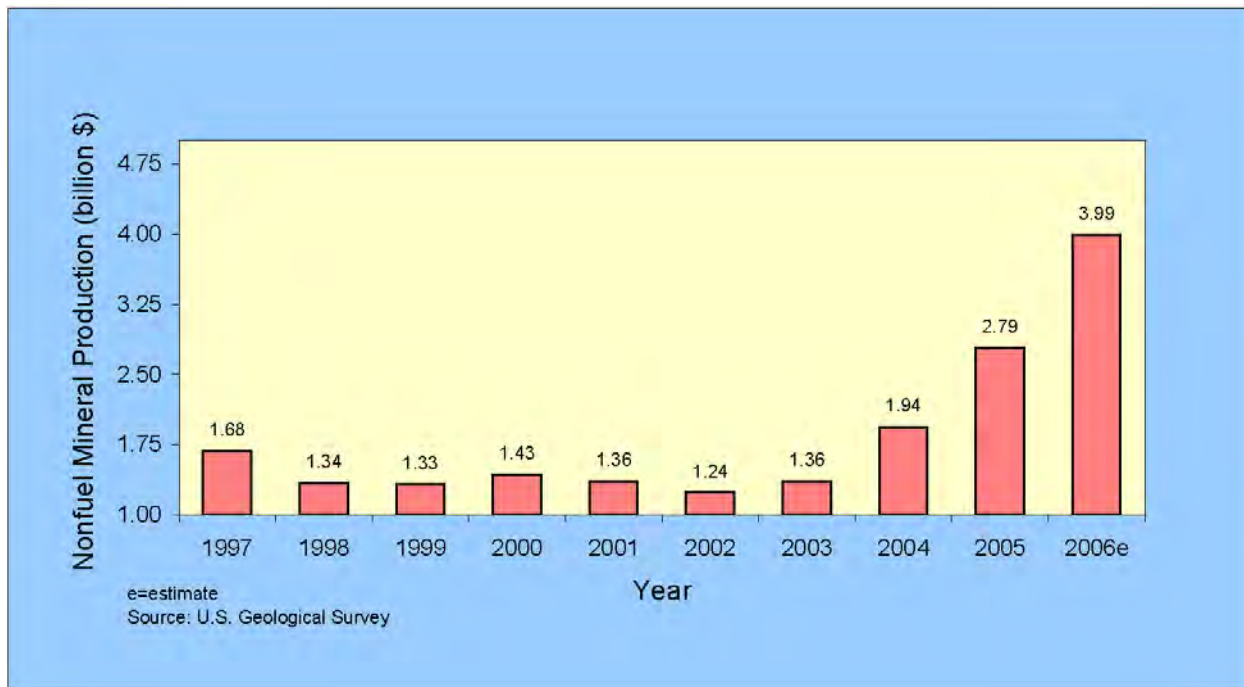
Table 1. Utah mineral production values in nominal dollars by industry segment from 1997 through 2006. Estimated value is in millions. Note that totals may not equal the sum of individual parts due to rounding.

<u>Year</u>	<u>Base Metals</u>	<u>Industrial Minerals</u>	<u>Coal</u>	<u>Precious Metals</u>	<u>Total Value</u>
1997	\$941	\$533	\$485	\$289	\$2,247
1998	\$688	\$534	\$474	\$154	\$1,850
1999	\$626	\$583	\$460	\$153	\$1,822
2000	\$749	\$500	\$456	\$212	\$1,916
2001	\$693	\$538	\$480	\$240	\$1,951
2002	\$612	\$565	\$467	\$172	\$1,815
2003	\$690	\$555	\$384	\$136	\$1,765
2004	\$1,136	\$643	\$386	\$158	\$2,324
2005	\$2,093 <sub>r</sub>	\$759 <sub>r</sub>	\$475 <sub>r</sub>	\$209 <sub>r</sub>	\$3,536 <sub>r</sub>
2006	\$2,885	\$811	\$588	\$400	\$4,684

r = revised

## BASE- AND PRECIOUS-METAL PRODUCTION

Base-metal production, with an estimated value of \$2.88 billion (an all-time high), was the largest contributor to the value of minerals produced in 2006 (figure 2; table 1). In



**Figure 3. Total annual value of Utah's nonfuel mineral production from 1997 through 2006.**

descending order of value, those metals were copper, molybdenum, magnesium, and beryllium. The 2006 base-metal values were about \$792 million (38%) more than 2005. This increase is on top of an 84% increase in 2005, and a 65% increase in 2004. Precious-metal production, valued at \$400 million (figure 2; table 1), includes gold (87% of total value) and silver (13% of total value). Precious-metal values in 2006 were \$191 million (91%) higher than in 2005.

Kennecott Utah Copper Corporation's (KUC) Bingham Canyon mine, located about 32 km (20 mi) southwest of Salt Lake City in Salt Lake County, is the state's major producer of copper, gold, and silver, and its sole producer of molybdenum. The combined value of minerals produced from the Bingham Canyon mine in 2006 was about 68% of the total value of all minerals produced statewide. KUC is in the third year of an aggressive mine expansion program.

### **Copper**

Copper was the largest contributor to the value of nonfuel minerals in Utah. Substantial price increases from 2003 through 2006 raised the value of copper to an all-time high, and the value of base-metal production statewide to a record of nearly \$2.9 billion. Refined copper production from Kennecott's Bingham Canyon mine decreased moderately in 2006 to approximately 218,000 metric tons (mt) (240,000 short tons [st]) from approximately 232,000 mt (255,000 st) in 2005 (Rio Tinto, 2007).

The Lisbon Valley Copper mine, located 72 km (45 mi) southeast of Moab in San Juan County, began operating in December 2005, but the SX-EW circuits did not start up until April 2006. The plant produced about 5260 mt (5800 st) of copper in 2006. Production will increase significantly in 2007 as the mine strives to reach full production capacity of 24,500 mt (27,000 st) per year.

## **Molybdenum**

Molybdenum was the second-largest contributor to the value of Utah's base-metal production in 2006. Kennecott's Bingham Canyon mine produced about 16,800 mt (18,480 st) of co-product molybdenum in 2006, about 8% more than in 2005 (Rio Tinto, 2007). The increased production of molybdenum was largely offset by a 35% drop in molybdenum metal prices during the year. The Bingham Canyon mine was the second-largest of nine molybdenum-producing mines in the U.S. in 2006, barely behind the Henderson mine in Colorado at 16,825 mt (18,550 st). The USGS reports that the U.S. mine output of molybdenum in concentrate increased only 4% in 2006, versus a 35% increase in 2005 (Magyar, 2007).

## **Gold and Silver**

Refined gold production in 2006 is estimated to be about 462,000 troy ounces (oz), a 25% increase from the 369,000 oz produced in 2005 (Rio Tinto, 2007). Gold is produced from two surface mines owned by Kennecott Corporation: one primary producer (Barneys Canyon mine) and one by-product operation (Bingham Canyon mine), both located in Salt Lake County. Several other small mines in the state are known to produce minor amounts of gold and silver, but production is not reported nor included in the above totals. The Barneys Canyon mine exhausted its economic ore reserves in late 2001 and ceased mining, but will continue to produce gold from its heap-leach pads at a much reduced rate into 2007, when those pads will be depleted. Silver is also a by-product metal from the Bingham Canyon mine. Refined silver production was 4.15 million oz in 2006 (Rio Tinto, 2007), about 17% higher than in 2005.

## **Magnesium**

Magnesium metal was the third-largest contributor to the value of base metals in 2006. Magnesium metal is produced from Great Salt Lake brines by US Magnesium, LLC at its electrolytic plant at Rowley in Tooele County. The plant's annual capacity is 43,000 mt (47,000 st) of magnesium metal (99.8% purity). It is the only active primary magnesium processing facility in the U.S. Magnesium production in 2006 was marginally higher than in 2005. Average magnesium metal prices declined from \$3.48/kg (\$1.58/lb) in 2004 to \$2.53/kg (\$1.15/lb) in 2006 (Kramer, 2007).

## **Beryllium**

Utah continues to be the nation's sole producer of beryllium concentrates. Brush Resources has a beryllium (bertrandite) mine in Juab County and a nearby processing plant. Ore and imported beryl can both be processed at the company's plant a few miles north of Delta in Millard County. The product (beryllium hydroxide) is then sent to the company-owned refinery and finishing plant in Ohio, where it is converted into beryllium metal, alloys, and oxide. The company reported mining approximately 53,000 mt (60,000 st) in 2006, in addition to purchasing about 45,000 mt (50,000 st) of beryl ore from the National Defense Stockpile. The company's Hogsback mine was closed in 2006 and overburden removal at the new Fluro-Roadside pit will begin in early 2007.

In 2005, Brush Wellman (parent company) was awarded a \$9 million contract under the Department of Defense's Defense Production Act, Title III Program. The contract is for the engineering and design of a new facility for the production of primary beryllium, the feedstock material used to produce beryllium metal products. The new facility, to be owned and operated by Brush Wellman, will be located at an existing plant site in Elmore, Ohio. Design and engineering will be completed in 2007. Additional funding will be required prior to construction, which will take two to three years (Brush Wellman, 2007). Shedd (2007) estimates that about 45% of beryllium use is in computer and telecommunications products, and the remainder is used in aerospace and defense applications, appliances, automotive electronics, industrial components, and other applications.

## **INDUSTRIAL-MINERALS PRODUCTION**

Industrial-minerals production, with an estimated value of \$811 million, an all-time high, was the second-largest contributor to the value of minerals produced in 2006 (figure 2; table 1). The value of industrial minerals has grown substantially over the past 10 years, increasing from \$533 million in 1997 to \$811 million this past year, a 52% increase. Commodities or commodity groups that have realized the majority of these gains include sand and gravel and crushed stone; Portland cement and lime; salines, including salt, magnesium chloride, potash (potassium chloride), and sulfate of potash (SOP); and phosphate rock. These commodities account for 89% of the total value of Utah's industrial minerals segment. Other important commodities produced in Utah, in descending order of value, include gilsonite, expanded shale, common clay, bentonite and kaolinite, and gypsum. While the overall value of industrial minerals reached a record high, several commodity groups, including salt and brines, phosphate, and expanded shale and perlite experienced lower values due to lower production and/or lower commodity prices in 2006.

### **Portland Cement and Lime**

Portland cement and lime were the largest contributors to the value of industrial minerals produced in 2006, with a combined value of \$238 million, about \$46 million (24%) more than in 2005. Two operators produce Portland cement in Utah: Holcim, Inc. and Ash Grove Cement Company. Holcim's Devils Slide mine and plant are located east of Morgan in Morgan County, and Ash Grove's Leamington mine and plant are east of Lynndyl in Juab County. The companies have a combined capacity of more than 1.4 million mt (1.5 million st) of cement annually. Both plants operated at or above design capacity in 2006, with total production of about 1.4 million mt (1.5 million st). In addition to limestone, Ash Grove Cement mines a modest amount of shale and sandstone that are used in the manufacture of cement.

Lime production was about 10% higher in 2006 than in 2005, with an estimated production of about 818,000 mt (900,000 st). There are two suppliers of lime in Utah, with a combined capacity of more than 0.9 million mt (1.0 million st) per year: Graymont Western U.S., Inc., which produces dolomitic quick lime and high-calcium quick lime; and Chemical Lime of Arizona, Inc., which produces dolomitic quick lime and hydrated dolomitic lime. Both operations serve markets in Utah and surrounding states. Graymont Western's plant is in the Cricket Mountains, approximately 56 km (35 mi) southwest of Delta in Millard County, and is

one of the 10 largest lime plants in the United States. Chemical Lime of Arizona's plant is about 13 km (8 mi) northwest of Grantsville in Tooele County.

Statewide, DOGM lists 35 active limestone operations including 17 Large Mine and 18 Small Mine permits. Total limestone production reported in 2006 was 3.20 million mt (3.52 million st). Other uses of limestone include construction as well as flue-gas desulfurization in coal-fired power plants. A small amount of limestone and dolomite is also crushed to a fine powder and marketed as “rock dust” to the coal mining industry.

### **Salt, Magnesium Chloride, Potash (Potassium Chloride), and Sulfate of Potash**

Brine-derived products, including salt, were the second-largest contributors to the value of industrial-mineral production in Utah during 2006, with a combined value of \$233 million, about \$29 million (11%) less than in 2005. The decrease in value is attributable to the lower production of all four commodities. In addition to salt, brine-derived products include magnesium chloride and potash (potassium chloride and potassium sulphate [SOP]). One company (North Shore Limited Partnership) produces a small amount of concentrated brine that is used as an ingredient in mineral food supplements. The statewide production of salt and other brine-derived products, excluding magnesium metal, is estimated to be 3.42 million mt (3.77 million st) in 2006, about 0.96 million mt (1.05 million st) less than in 2005. Potash production (including SOP) is estimated to be about 0.85 million mt (0.93 million st) in 2005, approximately 0.31 million mt (0.34 million st) less than in 2005.

Salt production alone was estimated to be 2.52 million mt (2.77 million st) in 2006, about 0.12 million mt (0.13 million st) less than in 2005, with most of the production coming from three operators processing brine from Great Salt Lake. The three largest operators are, in descending order of production: (1) Great Salt Lake Minerals Corporation, (2) Cargill Salt Company, and (3) Morton International. In addition, three other companies produce salt and/or potash from operations not located on Great Salt Lake: (1) Reilly Chemical Company at Wendover in Tooele County (salt and potash), (2) Moab Salt, LLC near Moab in Grand County (salt and potash), and (3) Redmond Minerals, Inc. near Redmond in Sanpete County (rock salt). In the past five years, Redmond Minerals has increased production significantly due to an aggressive marketing campaign.

### **Sand and Gravel, and Crushed Stone**

Sand and gravel, and crushed stone (including limestone and dolomite) were the third-largest contributors to the value of industrial minerals produced in Utah during 2006, with an estimated value of \$219 million, about \$23 million (12%) higher than in 2005. These materials are produced in nearly every county in Utah by commercial operators as well as county, state, and federal agencies. Due to the large number of operations (approximately 140 active pits and quarries), the UGS does not send production questionnaires to this group. However, production data are compiled by the USGS. Based on preliminary 2006 data (Tanner, 2007), the USGS estimates that 2006 production will be 34.5 million mt (37.9 million st) of sand and gravel with a value of \$160 million, and 9.7 million mt (10.7 million st) of crushed stone with a value of \$58.7 million. Crushed stone production includes raw materials for both lime and cement plants. This

is a 2% increase in sand and gravel production and a 17% increase in the production of crushed stone compared to 2005.

### **Phosphate**

Simplot Phosphates, LLC is Utah's only phosphate producer. The company's phosphate operation is 18 km (11 mi) north of Vernal in Uintah County. The mine produces roughly 2.7 to 3.6 million mt (3 to 4 million st) of ore annually, which is processed into 0.9 to 1.8 million mt (1 to 2 million st) of phosphate concentrate. The concentrate is transported in slurry form to the company's Rock Springs, Wyoming, fertilizer plant via a 144-km (90-mile) underground pipeline. During 2006, the mine produced about 3.5 million mt (3.8 million st) of ore, slightly more than in 2005.

### **Gilsonite**

Gilsonite production for 2006 is estimated to be about 73,000 mt (80,000 st), the same as in 2005. Gilsonite is an unusual solid hydrocarbon that has been mined in Utah for more than 100 years. Gilsonite is marketed worldwide for use in over 150 products ranging from printing inks to explosives. All of the gilsonite mines are located in southeastern Uintah County. The three companies that produce gilsonite, in descending order of production, are (1) American Gilsonite Company, (2) Zeigler Chemical and Minerals Company, and (3) Lexco, Inc. Gilsonite production has been increasing modestly over the past several years.

### **Expanded Shale and Perlite**

Two companies, Utelite, Inc. and Harborlite Minerals (formerly Basin Perlite), a subsidiary of World Minerals, produced lightweight "expanded" products from shale and perlite for use primarily in the construction and building industries. World Minerals is owned by Imerys, a French multinational company. Mine production was about 390,000 m<sup>3</sup> (300,000 cubic yards) in 2006, a slight increase from 2005. Utelite's shale mine and plant is east of the town of Wanship in Summit County. Harborlite Mineral's perlite mine is about 40 km (25 miles) north and east of the town of Milford in Beaver County, and the plant is located in Milford. The mine and plant were shut down in mid-2006 and are presently inactive.

### **Common Clay, Bentonite, and High-Alumina Clay**

Nearly 291,000 mt (320,000 st) of common clay and approximately 74,000 mt (81,000 st) of bentonite were produced by eight companies in 2006. Statewide, there were 19 active mine permits held by clay and/or bentonite operators in 2006. Many of these mines operate intermittently. The two largest producers of common clay in 2006 were Interstate Brick Company and Interpace Industries. Two companies (Western Clay Company and Redmond Minerals, Inc.) produce bentonite from pits located in central Utah. Sandy Nell produces a high-alumina clay from a pit in Beaver County, and Atlas Minerals is developing a high-alumina specialty clay (halloysite) mine in Juab County. More than 75% of all common clay is used in the manufacture of brick. Bentonite is used as a sealant in many civil engineering applications, as a pet-waste absorbent (litter-box filler), as an additive in oil and gas drilling fluids, and as a



binder in foundry molds. High-alumina clays are used in the manufacture of cement and in numerous specialty applications including the field of nanotechnology.

### **Gypsum**

Five companies produced about 467,000 mt (514,000 st) of gypsum in 2006, about 75,000 mt (83,000 st) more than in 2005. In descending order of production, the three largest producers were (1) Georgia Pacific Gypsum, (2) U.S. Gypsum Company, and (3) Sunroc Corporation (Clyde Companies). Georgia Pacific Gypsum and U.S. Gypsum operate the only two wallboard plants in Utah. Both plants are near the town of Sigurd in Sevier County. The Georgia Pacific plant, which closed in 2002, reopened in 2006 and is operating on a full-time basis. Statewide, there are 14 permitted gypsum mines; five are listed as active and nine are listed as inactive. Most gypsum produced in Utah is used for making wallboard, but several operators supply raw gypsum to regional cement companies where it is used as an additive to retard the setting time of cement, and to the agricultural industry for use as a soil conditioner.

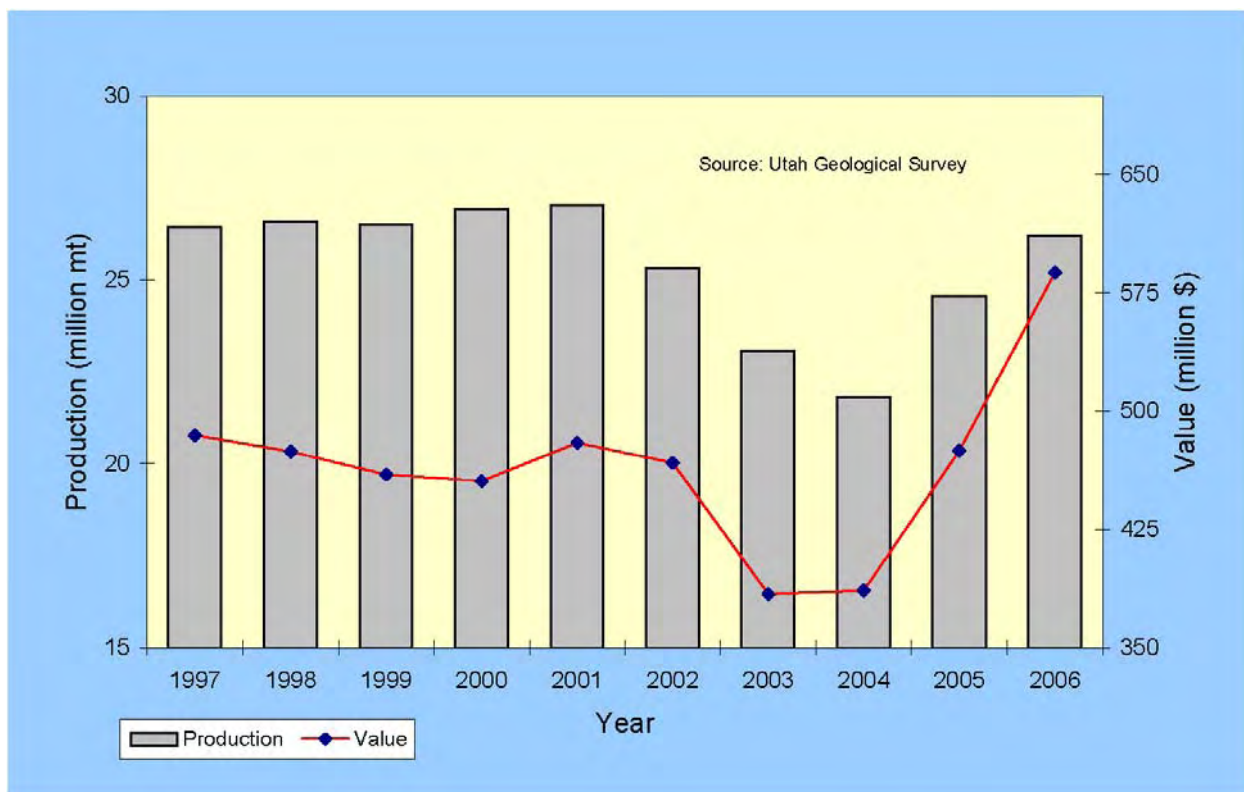
## **ENERGY MINERALS PRODUCTION**

### **Coal**

Utah's coal operators produced 23.8 million mt (26.2 million st) of coal valued at \$588 million from 13 underground mines in 2006 (figures 2 and 4; table 1). This production was approximately 1.5 million mt (1.6 million st), or 7% more than in 2005. All of the mines and coal-related facilities are located in east-central Utah (figure 5). Utah's synfuel plant, DTE Utah Synfuels, LLC, is the only synfuel facility located west of the Mississippi River. The synfuel plant is located at the Castle Valley (CV) railroad spur near the town of Wellington. The plant operated on a part-time basis in 2006, and processed about 1 million mt (1.1 million st) of high-ash coal purchased from several local coal operators. The DTE plant, which produces a solid synthetic product that is used to fuel cogeneration and traditional coal-fired power plants, is scheduled to close in 2008 because of the loss of synfuel tax credits. A new air-sparg processing plant that began operating in December 2005 processed about 109,000 mt (120,000 st) of raw coal during 2006. The plant is owned by Covol Technologies, a subsidiary of Headwaters, Inc., and is rated at about 226 mt (250 st) per hour. The plant is located just south of the CV spur. Arch Coal Company began operations at its new coal preparation plant in 2006. The plant is located along the CV spur and processes about 54,500 mt (60,000 st) of coal per month, almost all from the company's Dugout Canyon mine.

The largest coal producer was the Sufco mine, operated by Canyon Fuel Company, LLC, which produced a record-high 7.2 million mt (7.9 million st) of coal in 2006. In addition, the following four mines each produced in excess of 1.8 million mt (2.0 million st) of coal: (1) Aberdeen, operated by UtahAmerican Energy, Inc. (formerly Andalex Resources); (2) Deer Creek, operated by Energy West Mining Company (Rocky Mountain Energy); (3) Dugout Canyon, operated by Canyon Fuel Company, LLC; and (4) West Ridge, operated by West Ridge Resources.

The following three mines ceased operating in 2006 due to reserve depletion: Bear Canyon #3, operated by Co-op Mining Company; South Crandall, operated by Genwal



**Figure 4. Utah's annual coal production and value from 1997 through 2006.**

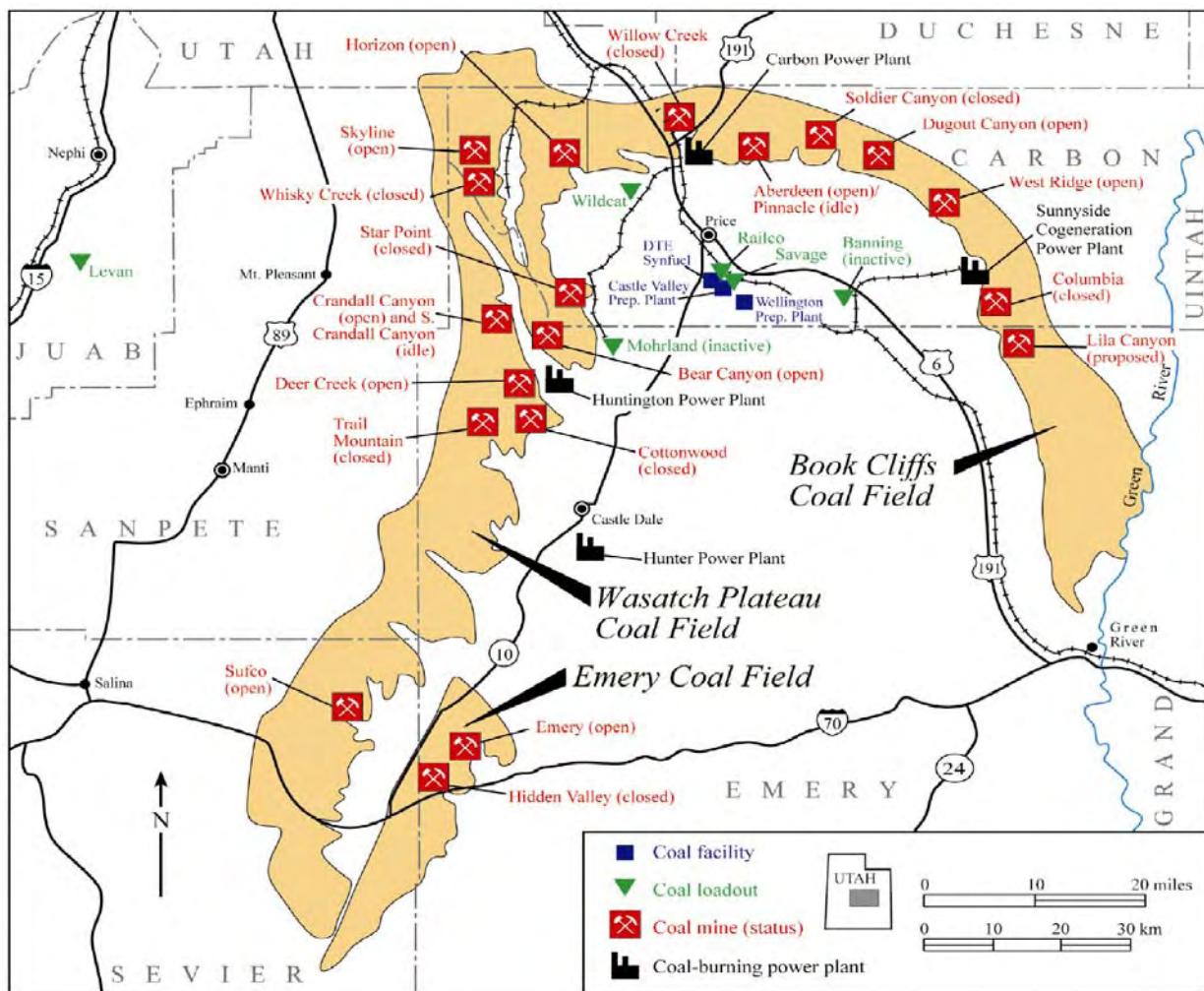
Resources; and Pinnacle, operated by UtahAmerican Energy, Inc. (figure 5). One potential new mine (UtahAmerican Energy Company's Lila Canyon mine) is in the final stages of permitting, but no plans have been announced to begin mine development. The surge in oil and gas prices that began in the fall of 2003 has positively affected coal prices and production, which are both anticipated to increase for the next several years. Approximately 60% of Utah's coal was consumed in-state by three electric utilities in 2006.

## EXPLORATION AND DEVELOPMENT ACTIVITY

Exploration and development work increased in Utah during 2006 because of the dramatic increase in world commodity prices from the all-time low in 2001 to the current new highs. Most efforts were focused on copper, molybdenum, iron, gold, silver, zinc, and uranium. Much of the information in this section is from numerous individual company websites and press releases.

### Claims, Leases, and Mine Permits

The number of new unpatented mining claims filed in the state has risen dramatically from a low of 508 in 2001 to over 6000 in 2006. The majority of claims were staked for uranium. San Juan County recorded the most new mining claims again in 2006 with more than 1100 followed by Grand and Beaver Counties, both with over 900 new claims. The projects and mining districts discussed below are shown on figure 6.



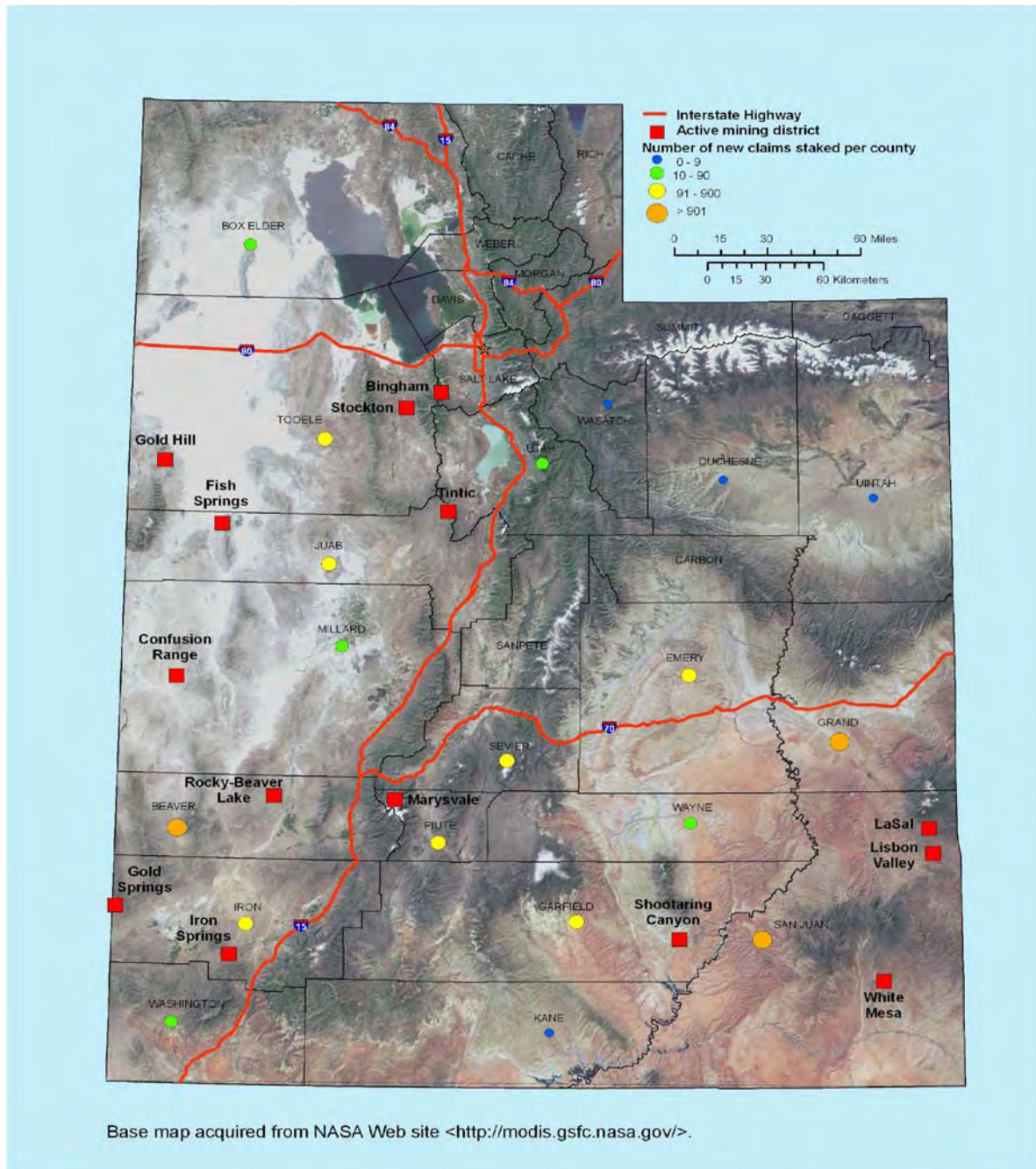
**Figure 5. Location and status of central Utah's coal mines and processing plants. Data from DOGM files.**

The Utah School and Institutional Trust Lands Administration (SITLA), which manages about 1.4 million hectares (3.4 million acres) of state-owned lands in Utah, reported issuing leases and/or contracts for the following commodities in 2005: metalliferous minerals-74, sand and gravel-18, bituminous/asphaltic sands-5, oil shale-5, mineral materials-3, clay-1, gemstone/fossil-1, geothermal-1, and unclassified-1. SITLA generated record revenues in fiscal year 2006 (William Stokes, SITLA, written communication, 2007).

During 2006, DOGM received five Large Mine permit applications (greater than 2 ha [5 acres] disturbance) and 41 new Small Mine permit applications (less than 2 ha [5 acres] disturbance). Four of the Large Mine permit applications were for industrial minerals operations and one was for a uranium operation. The 41 Small Mine permit applications were for the following operations: industrial minerals-28; energy minerals-6; precious-metals-4; gem, fossil, and other-2; and base metals-1. The number of Large Mine applications was five fewer than in 2005; Small Mine applications were three more than in 2005.

Reported mine production for 2006 is incomplete. In 2005, DOGM recorded production from 69 Large Mines (excluding sand and gravel), six fewer than in 2004. The Large Mines included three base-metal mines, two precious-metal mines, 13 coal mines, and 51 industrial-mineral mines (including gems, geodes, fossils, and other). Sixty-five Small Mines reported





**Figure 6. Major base- and precious-metals and uranium exploration projects, and number of new mining claims staked by county in Utah during 2006. Claim data from Utah BLM state office.**

production in 2005, 11 fewer than in 2004. These Small Mine permits included 35 industrial-mineral; 24 gems, geodes, fossils, and other; and six precious-metal operations.

Thirty-five Notices of Intent to explore on public lands were filed with DOGM in 2006, compared to 27 in 2005 and 14 in 2004.

## Base Metals

Base metals had an especially strong year in Utah, buoyed by record metal prices: the Bingham Canyon mine produced record profits, the new Lisbon Valley copper mine began production, another copper operation is poised to begin production near Milford, a company in the Iron Springs district is preparing to ship iron ore, and exploration is ongoing in numerous other districts across the state.

### Bingham Canyon

Kennecott Utah Copper Corporation's (KUC) Bingham Canyon mine earned a record \$1.8 billion in 2006 on increased copper, gold, and silver prices and a continued strong molybdenum price (figure 7). KUC delivered record molybdenum production along with increased copper and gold volumes as a result of higher grades mined in 2006. KUC is in the third year of an aggressive mine expansion program with current efforts concentrated on extending the mine life beyond the existing plan of 2017. Alternatives being studied include additional open-pit laybacks or various underground options.



***Figure 7. Kennecott Utah Copper Corporation's Bingham Canyon Cu-Mo-Au-Ag mine, Salt Lake County, Utah (July 2005). View is toward northeast.***

Development work at Bingham Canyon in 2006 included an upgrade of the molybdenum circuit and the commissioning of a pebble crushing unit. Other major work during the year included the initial driving of a horseshoe-shaped drainage tunnel from near the bottom of the pit to the southwest.

Brownfield exploration at Bingham Canyon continued with substantial efforts at examining high-grade molybdenum areas, copper porphyry roots, and skarn zones below the currently defined ultimate pit. These efforts included more than 30,000 m (100,000 feet) of development drilling completed in 2006 (Michael Penick, written communication, 2007). Plans for 2007 include the re-excavation of the North Ore Shoot shaft collar, which was buried by the canyon dump.



## Lisbon Valley Copper

While Lisbon Valley Mining Company began mining and stacking the leach pads in 2005, plant construction at the new open-pit, heap leach, solvent extraction-electrowinning (SX-EW) copper operation was completed in 2006. Lisbon Valley commissioned the SX circuit in March and began harvesting the first cathodes in April. The operation continued to endure startup problems throughout the remainder of the year as it attempted to ramp up to full production. Production in 2006 was 5300 mt (5800 st) of copper and by the end of the year production was running at about 900 mt (1000 st) per month. Copper mineralization at Lisbon Valley occurs as disseminated and fracture-controlled copper in Cretaceous sandstones along the nose of a salt-cored anticline.

Exploration by Lisbon Valley during 2006 focused on evaluating the Flying Diamond deposit, discovered under cover a few miles southeast of the open-pit operation (figure 8). Drilling in 2006 expanded on the original 13 holes drilled in 2005 and included 24 core holes totaling 2818 m (9247 feet) and 23 rotary holes totaling an additional 4298 m (14,100 feet). These holes were generally laid out as fences perpendicular to the ore-controlling east splay of the Lisbon Valley fault, and help to define a mineralized zone approaching 2440 m (8000 feet) long by about 152 m (500 feet) wide. The average mineralized intercept is roughly 18 m (60 feet) thick with grades of about 0.35% copper. Mineralization is hosted in the same Cretaceous-age sandstone host horizons being mined to the northwest. About 16 km (10 miles) of shallow seismic surveying was performed in an area around Flying Diamond during the year to help define the ore-controlling structure (Gary Parkison, written communication, 2007).



**Figure 8.** *Drill rig at Lisbon Valley's Flying Diamond prospect, San Juan County, Utah.*

## **Rocky-Beaver Lake**

Western Utah Copper Company (WUCC) controls over 40,500 ha (100,000 acres) in the Milford area and has been actively exploring the Rocky and Beaver Lake mining districts for the past several years. The districts host seven partially defined copper skarn and breccia pipes with by-product gold and silver. In 2006, WUCC's exploration concentrated on definition drilling at the Candy B and Hidden Treasure targets. Current proven ore reserves total approximately 2.2 million mt (2.4 million st) averaging 1.38% total copper with a total mineral resource of an estimated 36 million mt (40 million st) of similar grade. Operating plans call for open-pit mining, column flotation, acid vat leaching, followed by electrowinning. In 2006, WUCC prepared the area of the plant site for construction (Western Utah Copper Company, 2006-2007). The company has a Large Mine permit application pending.

## **Iron Springs**

Palladon Iron Corporation acquired the Iron Mountain project in 2005. The property (former Comstock-Mountain Lion open-pit) hosts an estimated resource of about 16 million mt (18 million st) averaging 52% iron. The ore occurs as massive replacement/skarn deposits adjacent to Miocene laccoliths. In 2006, Palladon digitized the old US Steel/Geneva Steel drill data, began engineering and metallurgical studies for a new 2 million mt (2.2 million st) per year mill/concentrator, refurbished a used ball mill, demolished all of the existing structures on the mill site, and constructed an interchange with the Union Pacific Railroad for shipping ore to a port in California for processing in China (Palladon Ventures, 2006-2007).

## **Fish Springs**

Lithic Resources Ltd. acquired the Crypto zinc skarn in the Fish Springs mining district of western Juab County in 2005. In 1993, Cyprus Amax Minerals Company estimated a shallow oxide resource on the property of 2.8 million mt (3.1 million st) averaging 7% zinc and a deep sulfide resource of 5.4 million mt (6 million st) averaging 8.8% zinc. In 2006, Lithic completed 1028 km (643 miles) of helicopter-borne magnetic surveying at a line spacing of 100 m (328 feet), approximately 25 km (16 miles) of pole-dipole IP (induced polarization) surveying on lines spaced 200 m (656 feet) apart, and 1:8,000-scale, color aerial photography over the general property area. Plans for 2007 include a 10,000-m (33,000-foot) drilling program, the main objective of which will be to expand the Crypto zinc deposit (Chris Staargaard, written communication, 2007).

## **Stockton**

Kennecott Exploration continued their exploration of the Stockton porphyry copper system, about 16 km (10 miles) southwest of Bingham. Kennecott performed detailed geologic mapping, geochemical sampling, a gravity survey, 3-D IP survey, a ground magnetic survey, digitizing of the 56 km (35 miles) of underground workings, and drilling. Kennecott completed three new core holes totaling 1695 m (5561 feet). In addition, the company is sponsoring M.S.

thesis work on the district through Dr. William Chavez at the New Mexico Institute of Mining and Technology (Joey Wilkins, written communication, 2007).

### **Miscellaneous Base-Metal Developments**

In other base metal developments in Utah, (1) Chief Consolidated Mining Company was working on obtaining appropriate permits for renewed mining at the Burgin mine in the East Tintic district, (2) Inland Exploration acquired several interesting properties in west-central Utah, (3) Franconia Minerals Corporation drilled five holes looking for zinc-rich mantos at the Horn Silver mine in the San Francisco district, (4) Grand Central Silver Mines drilled several holes on the west fringe of the Bingham mining district, (5) Unico, Inc. continued work on the Deer Trail mine near Marysville in central Utah, and (6) Allegheny Technologies announced plans to construct a titanium sponge plant near the U.S. Magnesium facility at Rowley.

### **Precious Metals**

Strong prices for precious metals over the past couple of years have significantly increased the level of gold and silver exploration activity in Utah. Most of these efforts are focused in the eastern Basin and Range Province of western Utah.

### **Gold Springs**

The Gold Springs mining district is located on the Nevada-Utah border in southwestern Utah. Astral Mining Corporation drilled 10 reverse circulation (RC) holes totaling 1762 m (5780 feet) on a low-sulfidation, epithermal, gold-silver quartz vein swarm. The best hole (GS-06-1) cut 6.1 m (20 feet) of 7.24 ppm gold and 28.9 ppm silver at a depth of 25.9 m (85 feet). A 1500-m (5000-foot) core-drilling program is planned for 2007 (Astral Mining Company, 2006-2007).

### **Fish Springs**

The Silver Dome property, controlled by Columbus Gold Corporation, consists of approximately 760 ha (1880 acres) south of the Crypto zinc skarn. Silver mineralization at Silver Dome occurs in flat-lying Ordovician calcareous sandstones as fine-grained argentiferous galena, both disseminated and along high-angle structures. Initial mapping and sampling has identified mineralization, typically containing values ranging from 15 to 100 ppm silver, in a zone along the range front measuring 1000 by 100 m (3300 by 330 feet). The target at Silver Dome is bulk-mineable silver mineralization amenable to open-pit development (Columbus Gold Corporation, 2006-2007). Columbus Gold is currently carrying out more detailed geologic mapping, sampling, and trial geophysical surveys. The prospect area has never been drilled.

### **Gold Hill**

Dumont Nickel continued its exploration efforts in the Gold Hill mining district in southwestern Tooele County. The company drilled four RC holes in the Kiewit gold zone, seven RC holes in the Kiewit West target, and an additional seven shallow holes in the Cane Springs property. Late in 2006 they discovered a sediment-hosted gold system, the Rattler project, in the



northwestern portion of their property. Plans for 2007 include drill testing the Rattler targets (Dumont Nickel, Inc., 2006-2007).

### **Confusion Range**

Maestro Ventures acquired the Kings Canyon sediment-hosted gold property in southwestern Millard County. The property was explored in the early 1990s, primarily by Crown Resources. The property contains several gold zones with the largest defined resource holding about 6.2 million mt (6.8 million st) averaging 1 ppm gold (Maestro Ventures Ltd., 2006-2007).

### **Miscellaneous Precious-Metal Developments**

In other precious metal developments, (1) Deep Creek Exploration has staked and completed preliminary exploration work in the Sand Pass/Chalk Hills area of southern Juab County, (2) Cordex was actively examining properties in the Basin and Range Province of western Utah, (3) Miranda Gold Corporation staked the Lookout Pass sediment-hosted gold property in southeastern Tooele County, and (4) WUCC acquired property near the old Drum sediment-hosted gold mine.

### **Uranium**

The dramatic rise in the price of uranium over the past several years has had a substantial impact on exploration and development activity in Utah. Historically, Utah has been the third most productive uranium state. The majority of the uranium property acquisition and work has focused on the Colorado Plateau (Gloyn and others, 2005), where the Pandora mine has become the first reactivated uranium mine in Utah.

In late 2006, Denison Mines Corp. acquired International Uranium Corp. and all of its assets in Utah including the White Mesa uranium mill, Pandora mine, and the Henry Mountains Complex. Currently, the permitted and operating 1800 mt/d (2000 st per day), dual-circuit White Mesa uranium-vanadium mill near Blanding is processing alternate feed waste materials. The company began a \$15 million upgrade to the mill, which is expected to produce more than 3 million pounds of  $U_3O_8$  and 4.5 million pounds of  $V_2O_5$  by 2010.

In late 2006, Denison Mines' Pandora mine, in the eastern La Sal district, resumed uranium production, becoming the first productive uranium mine in Utah since 1991. In 2006, production totaled approximately 1090 mt (1200 st) of ore, which was stockpiled at the mine site. Reserves at the Pandora mine are estimated by the UGS at approximately 263,000 mt (290,000 st) at 0.22%  $U_3O_8$ . The Pandora ore will be shipped about 110 km (70 miles) south to the White Mesa mill and stockpiled until the mill circuits are converted from the current alternate feed to new ore feed in early 2008 (Jon Showalter, Denison Mines, personal communication, 2007).

Denison Mines' Henry Mountains Complex (Tony M mine and Bullfrog property) in the Shootaring Canyon district is believed to host the largest known uranium resource in Utah, estimated at about 4.9 million mt (5.4 million st) averaging 0.22%  $U_3O_8$ . Mining permits for this operation are pending from DOGM. Mining at the Henry Mountains Complex is scheduled to

resume in 2007. In addition, Denison Mines is planning a large drilling campaign near its mines in 2007.

Two other companies, Mesa Uranium Corp. and Universal Uranium Ltd., have interlocking property positions and ongoing drill programs in the Lisbon Valley mining district – Utah’s most productive uranium district at 35 million kg (78 million pounds)  $U_3O_8$ . Both exploration programs are designed to test the down-dropped northeastern side of the Lisbon Valley anticline. Mesa completed 10 holes in 2006 with a total depth of 8132 m (26,680 feet) and intersected strongly anomalous uranium mineralization in two holes. Mesa also drilled three additional holes on their adjoining North Alice mine target and cut anomalous uranium and copper in two of these holes (Mesa Uranium Corp., 2006-2007). Universal drilled 12 holes totaling 9382 m (30,780 feet) in 2006 and intersected anomalous uranium mineralization in six of the holes. In a second phase of drilling, Universal drilled eight additional holes totaling 6248 m (20,500 feet) with another 10 holes planned for 2007 (Universal Uranium Ltd., 2006-2007).

Several companies have acquired property containing known uranium resources. Energy Metals Corp. acquired the Velvet property (210,000 mt [231,000 st] averaging 0.43%  $U_3O_8$ ) in the Lisbon Valley district, the Frank M resource (1.36 million mt [1.5 million st] averaging 0.12%  $U_3O_8$ ) in the Shootaring Canyon district, and the San Rafael property (587,000 mt [647,000 st]) averaging 0.16%  $U_3O_8$ ) in the Green River area (Energy Metals Corporation, 2006-2007). The San Rafael property is a joint venture with Magnum Uranium Corp., which also controls three other uranium properties in Utah.

SXR Uranium One, Inc. acquired the uranium assets of the U.S. Energy Corp. in 2006, including the Shootaring Canyon uranium mill in the Henry Mountains area and several Utah uranium prospects. The 680 mt/d (750 st per day) mill is being re-permitted for operation. Their Utah properties include the Sahara mine (99,000 mt [109,000 st] averaging 0.23%  $U_3O_8$ ) in the San Rafael River uranium district (SXR Uranium One, Inc., 2006-2007).

Trigon Exploration Canada Ltd. acquired a volcanic-hosted uranium property in the Central Mining Area near Marysvale. Historical drilling data suggest a resource estimated at 680,000 mt (750,000 st) averaging 0.075%  $U_3O_8$ . Magnum Uranium Corp. also has acquired property in the Marysvale area (Trigon Uranium Corp., 2006-2007). Other companies pursuing uranium exploration plays in Utah during 2006 include Uranium Energy, International Ranger, Blue Rock Resources, Homeland Energy, Global Uranium, Energy Fuels Resources, and Max Resources.

## NEW MINERALS INFORMATION

The following publications provide new information on the mineral resources of Utah. These publications and others are listed on the UGS website at <<http://geology.utah.gov/>> and are available for purchase at the DNR Map and Bookstore. Additional free geographic information system (GIS) data on Utah is available for download at <<http://agrc.its.state.ut.us/>>.

*Mining Districts of Utah*, edited by Roger Bon, Robert Gloyn, and Gerald Park, was released on compact disk (CD) as Utah Geological Association (UGA) Publication 32. The CD contains over a dozen papers on the history, production, and geology of individual Utah mining districts, including most of the largest districts: Bingham, Park City, Tintic, Lisbon Valley, Spor Mountain, and Stockton. Also included are ancillary papers on the history of metal prices and mining in Utah.

A collection of reprints, *Uranium/Vanadium Publications of the Utah Geological Survey*, was released as UGS Open-File Report 462. This CD contains 14 publications totaling 1418 pages and 14 plates. Included in this collection is the most complete publication (Uranium-Vanadium Occurrences of Utah) on uranium in Utah.

Another collection of reprints, *Selected Lead and Zinc Publications of Utah*, compiled by Ken Krahulec was released as UGS Open-File Report 466. The CD contains 10 papers totaling 759 pages, including the most comprehensive work to date on Utah base metal mines.

*Geology of Northwestern Utah*, UGA Publication 34, is a CD edited by Kimm Harty and David Tabet. The CD contains five papers on mineral resources, including articles on the Dugway mining district; Vipont mine in the Ashbrook district; travertine at Aragonite; Mountain City district; and limestone, dolomite, and silica occurrences of northwestern Utah.

Other recent publications from the UGS on minerals and energy resources include (1) *Coal Resource Map of Utah* (Map 226DM), (2) *The Available Coal Resource for Eight 7.5-minute Quadrangles in the Alton Coalfield, Kane County, Utah* (Special Studies 118), (3) *Utah Oil Shale Database* (Open-File Report 469), and (4) *History and Mineral Resource Characterization of Sevier Lake, Millard County, Utah* (Miscellaneous Publication 06-6). In addition, Tripp and White (2006) reported on gilsonite resources and mining in the Uinta Basin.

## **RECLAMATION AND THE ENVIRONMENT**

The U.S. Department of Energy and the State of Utah agreed in 2005 to move the 10.5 million mt (11.9 million st) of uranium mill tailings located along the Colorado River near Moab. The tailings are estimated to average about 100 ppm uranium and 400 ppm vanadium (Don Metzler, personal communication, 2007). The tailings will be moved 48 km (30 miles) north to a site near Crescent Junction, Utah. Cleanup operations and revegetation peripheral to the Moab tailings was done in 2006. Disposal cell construction at Crescent Junction is not expected to begin before 2009.

Reclamation at the Midvale slag Superfund site is complete and the site along the Jordan River is undergoing mixed-use development as Bingham Junction. Scheduled development includes 48 ha (119 acres) of houses, apartments, retail, and office space with an additional 4.5 ha (11 acres) of wetland.

DOGM continued its program of closing abandoned mines. The program has already closed an estimated 6000 to 7000 openings and has four new projects in the works for 2007: Star district, San Rafael Swell, Gold Hill district, and the Mammoth section of the Tintic district. These four projects include an additional 1000 openings.

A consortium of Tiffany & Co., Snowbird Ski Resort, Environmental Protection Agency, and Trout Unlimited teamed up to reclaim the abandoned Pacific mine in the American Fork district. The cleanup, which had been hindered by the 1971 Clean Water Act, was completed under a special Good Samaritan variance from the Act.

Shaw Environmental, Inc. mined approximately 202,000 m<sup>3</sup> (264,000 cubic yards) of limestone from their Lime Peak quarry in the Tintic district to be used for rip rap in the remediation of historical mine dumps near the town of Eureka.

## OUTLOOK

The overall value of mineral production in Utah is expected to be lower in 2007 because of projected lower base- and precious-metal production and lower average base-metal prices. Industrial-mineral production is expected to be flat as many operators are operating at or near capacity. Overall, industrial-mineral prices will continue to remain relatively high as the regional demand for most industrial minerals will continue to be strong in 2007. The value of coal will increase as production and prices are expected to increase as new contracts at significantly higher prices replace existing contracts. The opening of the Lisbon Valley copper mine in late 2005 added incrementally to the state's base-metal value in 2006 and will increasingly contribute as the mine ramps up to full production.

Although it appears that copper, gold, and silver prices peaked in mid-2006, overall metal prices for the 2007 calendar year may still be substantially similar to the strong prices of 2005, with the exception of molybdenum and uranium. Molybdenum's surprising price run-up in 2005 seems unlikely to be repeated in 2007, and the uranium spot price continued to escalate throughout 2006 and appears headed into record territory in 2007. The remarkable recent upsurge in molybdenum and uranium prices has led to investor speculation in the spot markets for these commodities which, it is feared, may lead to enhanced price volatility in these commodities.

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## FIGURE CAPTIONS

Figure 1. Total annual value of Utah's mineral production, inflation adjusted to 2006 U.S. dollars.

Figure 2. Value of Utah's annual mineral production shown in millions of dollars, by sector, from 2002 through 2006.

Figure 3. Total annual value of Utah's nonfuel mineral production from 1997 through 2006.

Figure 4. Utah's annual coal production and value from 1997 through 2006.

Figure 5. Location and status of central Utah's coal mines and processing plants. Data from DOGM files.

Figure 6. Major base- and precious-metals and uranium exploration projects, and number of new mining claims staked by county in Utah during 2006. Claim data from Utah BLM state office.

Figure 7. Kennecott Utah Copper Corporation's Bingham Canyon Cu-Mo-Au-Ag mine, Salt Lake County, Utah (July 2005). View is toward northeast.

Figure 8. Drill rig at Lisbon Valley's Flying Diamond prospect, San Juan County, Utah.