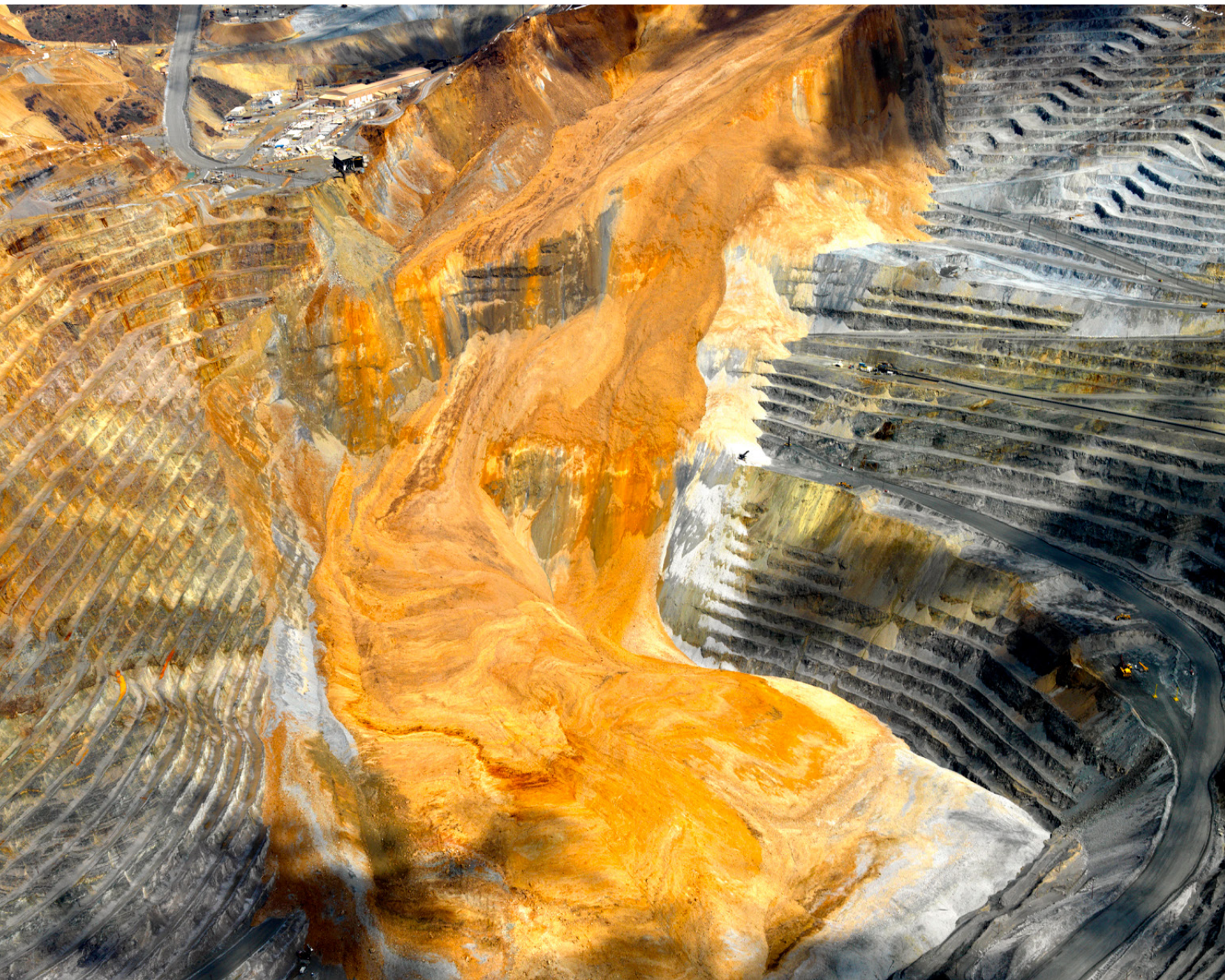


UTAH'S EXTRACTIVE RESOURCE INDUSTRIES 2013

by Taylor Boden, Michael Vanden Berg, Ken Krahulec, and Andrew Rupke



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Cover photo: *The Manefay landslide at the Bingham Canyon open pit copper mine on April 10, 2013, was the largest slide in mining history. Notably the slide resulted in no injuries or deaths. The slide deposited about 149 million short tons of waste rock in the bottom of the pit. This view, toward the northeast, shows the landslide in its entirety with the main failure plane angling downward from the right side of the headwall scarp toward the buildings in the middle left. The slip plane is in the Manefay series beds at the base of the Upper Bingham Mine Formation (Upper Pennsylvanian). Also notable are the two different slides—the early light-gray slide of pyritized Upper Bingham Mine Formation quartz sandstones overlain by the yellow-brown historical, oxidized dump material that slid about 1.5 hours later. Also apparent is the fluidity of the slide as shown by the banding in the foot of deposit in the pit bottom.*
Photo courtesy of Kennecott Utah Copper.



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ABSTRACT

During 2013, Utah extractive resource industries produced energy and mineral commodities with an estimated gross value of \$9.5 billion. On an inflation-adjusted basis, this is a \$1 billion (12%) increase from 2012, and \$1.2 billion (11%) less than the 2008 record high of \$10.7 billion. Total energy production in 2013 was valued at \$5.6 billion, which includes \$2.96 billion from crude oil production, \$2.11 billion from natural gas and natural gas liquids production, and \$0.58 billion from coal production. Nonfuel mineral production was valued at \$3.9 billion, including \$2.21 billion from base metal production, \$1.3 billion from industrial mineral production, and \$0.37 billion from precious metal production.

U.S. Geological Survey preliminary 2013 data ranked Utah 7th nationally in the value of nonfuel mineral production, accounting for approximately 4.5% of the United States total. In 2013, copper was the largest contributor to the value of nonfuel minerals in Utah, having an estimated value of \$1.66 billion and mostly produced from Kennecott Utah Copper Corporation's Bingham Canyon mine. The largest overall contributors to the value of industrial mineral production in Utah during 2013 were the brine-derived products potash, salt, and magnesium chloride, which had an estimated value of \$485 million. Notably, Utah remains the only state in the nation to produce magnesium metal, beryllium concentrate, and gilsonite.

From 2012 to 2013, oil and gas exploration and development activity in Utah declined, with the number of permitted wells decreasing from 2105 to 1611, and the number of drilled wells decreasing from 1107 to 991. Utah coal production decreased 1.2% in 2013, with a further decrease expected in 2014 due to weak domestic demand. Continuing low uranium prices in 2013 resulted in a halt to production from uranium mining operations in Utah. Mineral exploration and development also declined relative to 2012, with exploration focused primarily on potash, phosphate, and gold. Less than 2000 new unpatented mining claims were filed in Utah in 2013, with 19,487 active unpatented mining claims remaining on file with the Bureau of Land Management at the end of the year. The numbers of new claims and active claims both declined during 2013.

INTRODUCTION

Background

Utah mineral activity summaries have been compiled annually by the Utah Geological Survey (UGS) since 1989. To maintain uniformity and continuity, the general style used in previous editions of this report will be continued. However, the title was changed to *Utah's Extractive Resource Industries* in 2012 to reflect the addition of crude oil, natural gas, and unconventional fuels sections. Final 2012 production and economic values became available in the fourth quarter of 2013, and for this report we used those numbers to update values published in *Utah's Extractive Resource Industries 2012* (Boden and others, 2013). Note that nonfuel mineral production values reported by the U.S. Geological Survey (USGS) may differ from those reported by the UGS, due to different data compilation methods. The 1997–2013 Utah mineral/mining summaries are available on the UGS website at <http://geology.utah.gov/utahgeo/rockmineral/index.htm#minactivity>.

Since 1993, Utah mineral industry activity summaries have categorized mineral production and economic value into four broad segments consisting of base metals, precious metals, industrial minerals, and energy minerals (coal and uranium). In 2011, the annual Utah coal report was combined with the mineral activities summary (Gwynn and others, 2011), and in 2012 new sections on crude oil, natural gas, and unconventional fuels were added (Boden and others, 2012). The USGS, U.S. Energy Information Administration (EIA), and the Utah Division of Oil, Gas, and Mining (DOGM) provided much of the data compiled for this report. Additional data were obtained by the UGS from operator surveys, company websites, trade industry publications, and personal correspondence.

Historical Context

Utah contains a remarkable variety of energy and mineral resources. The development of these resources for over 160 years has been important to Utah and the United States. Mining has played a vital role in Utah's economy and is the oldest nonagricultural industry in the state, employing thousands directly in mining, processing, and transportation, and indirectly in supporting occupations. The recorded mining history of Utah began in 1847. Soon after their arrival, Latter Day Saint pioneers began developing mineral resources. Their early efforts included recovering salt from Great Salt Lake,

coal mining (near the communities of Coalville, Wales, and Cedar City), quarrying building stone, and production of clay and lime products (Alexander, 2006).

With the arrival of the Third California Infantry under Colonel Patrick E. Connor came the discovery of significant base and precious metal deposits in the 1860s at Bingham Canyon and Stockton in the Oquirrh Mountains, as well as in Little Cottonwood Canyon and the Park City area in the Wasatch Range (Krahulec, 2006). After the completion of the transcontinental railroad in 1869, branch lines were developed to access mining districts and ore produced in Utah became more valuable, exceeding a value of \$100 million by 1917 (Stowe, 1975). With development of mining and transportation infrastructure Utah became one of the largest mining and smelting centers in the western U.S. by the early 1900s. Porphyry copper mining began in Bingham Canyon in 1904, and even today, copper, gold, silver, and molybdenum produced from the deposit makes it one of the most valuable operations in the U.S. Utah is also the nation's only source of gilsonite (since the late 1880s; Boden and Tripp, 2012), beryllium (since 1969; Alexander, 2006), and magnesium metal (since 1972; Krahulec, 2006). Demand for uranium used in nuclear weapons and power plants resulted in the development of uranium deposits in southeastern Utah during the 1950s and 1960s. In 1952, Charlie Steen discovered the biggest uranium deposit on the Colorado Plateau and developed the Mi Vida mine in the Big Indian Wash (Lisbon Valley) area of San Juan County. Oil and gas exploration in Utah extends back over 100 years. The first natural gas discovery in Utah was accidental, when gas was encountered in 1891, while drilling a water well in Farmington Bay on the eastern shore of Great Salt Lake (UGS, 2006). Gas from this area was later transported by wooden pipeline to Salt Lake City. Oil was discovered in the early 1900s at Rozel Point on the shore of Great Salt Lake in Box Elder County, and near the towns of Mexican Hat in San Juan County and Virgin in Washington County (UGS, 2006). By 1960, Utah was the 10th largest oil-producing state in the nation.

In 1969, the annual value of minerals produced in Utah had grown to \$500 million (Stowe, 1975), and it surpassed \$1 billion in 1988 (Walker and Smith, 1989). According to data compiled by the UGS, USGS, and other sources, the nominal value of Utah energy and mineral production reached a record high in 2008 of \$10 billion. The worldwide recession beginning in late 2008 is reflected in the decreased value of Utah's energy and mineral production in 2009. Since then, the ongoing economic recovery resulted in a relatively high value for Utah energy and mineral production in 2013.

The contribution of energy and mineral production to the Utah Gross Domestic Product (GDP), compared to the value of all goods and services statewide, decreased from 6% in the 1960s to 1.3% in the early 2000s as the state economy grew and diversified. However, the contribution of the energy and mineral industries to the Utah GDP recently rebounded to a high of 2.5% in 2008, and 2% in 2012 (U.S. Bureau of Economic

Analysis, 2014). The demand and price for Utah energy and mineral commodities will likely continue to rise, and the extractive resource industries are expected to remain an important contributor to the Utah economy.

Industry Overview

Based on UGS and USGS data, the estimated gross value of Utah energy and mineral production during 2013 was \$9 billion (nonfuel value from USGS, 2014a), which is 5% more than the 2012 inflation-adjusted value (figure 1). The 2013 energy and mineral production value is the third highest since the 2008 record of \$10.7 billion. From 2012 to 2013, prices for most base and precious metals decreased, while prices for most industrial minerals slightly increased and oil and gas prices remained relatively high. Despite a large decrease in molybdenum production from Kennecott Utah Copper (KUC), their significantly higher copper production in 2013 resulted in a higher value for base metals than in 2012. Increased production of precious metals in 2013 was offset by lower prices resulting in lower precious metal values. However, due to copper's large share of metals value, the overall value of metals increased slightly during 2013. Industrial minerals value grew for the third consecutive year. This growth was supported by construction projects and high production and prices for brine-derived potash products. The value of Utah coal decreased in 2013 as coal production hit a 20-year low. Demand for coal by electric utilities was constrained by the recession-related drop in demand for electricity. Demand was further diminished as several out-of-state power plants have converted from coal to natural gas. The combined value of Utah oil and gas production increased significantly during 2013. The increase in the value of oil largely followed increased oil production, whereas the increased value of natural gas resulted from higher gas prices as Utah natural gas production decreased in 2013. Energy Fuels Resources suspended production of uranium and vanadium from its Utah mines in 2013, because of low uranium prices. However, the company continued to process stockpiled uranium and vanadium ore at its White Mesa mill near Blanding in San Juan County.

The UGS's estimated value of energy resources produced in Utah during 2013 was \$5.6 billion, and nonfuel mineral resource production was \$3.9 billion. The oil industry sector contributed the largest value (\$2.96 billion; 31% of total), followed by base metals (\$2.21 billion; 23% of total), natural gas including natural gas liquids (\$2.11 billion; 22% of total), industrial minerals (\$1.3 billion; 14% of total), coal (\$579 million; 6% of total), and precious metals (\$365 million; 4% of total) (figures 2 and 3; table 1). Compared to 2012, the 2013 values for natural gas increased by \$358 million (20%), oil by \$463 million (19%), base metals by \$106 million (5%), and industrial minerals by \$20 million (2%), whereas precious metals decreased by \$39 million (-10%), and coal by \$35 million (-6%).

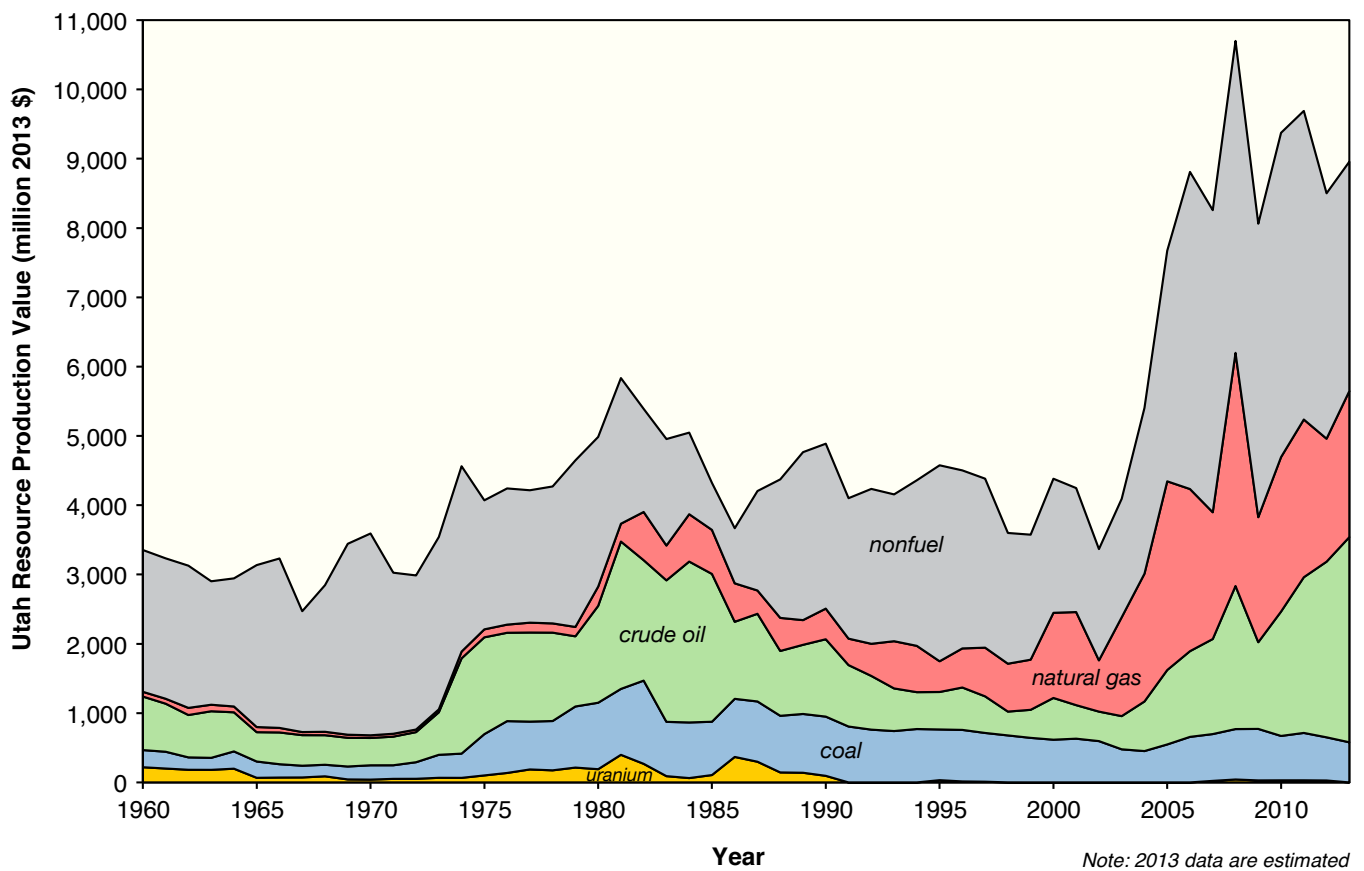


Figure 1. Annual value of Utah energy and mineral production, inflation adjusted to 2013 dollars, 1960–2013. Source: Nonfuel resource values from the U.S. Geological Survey (USGS, 2014a), all other from the Utah Geological Survey.

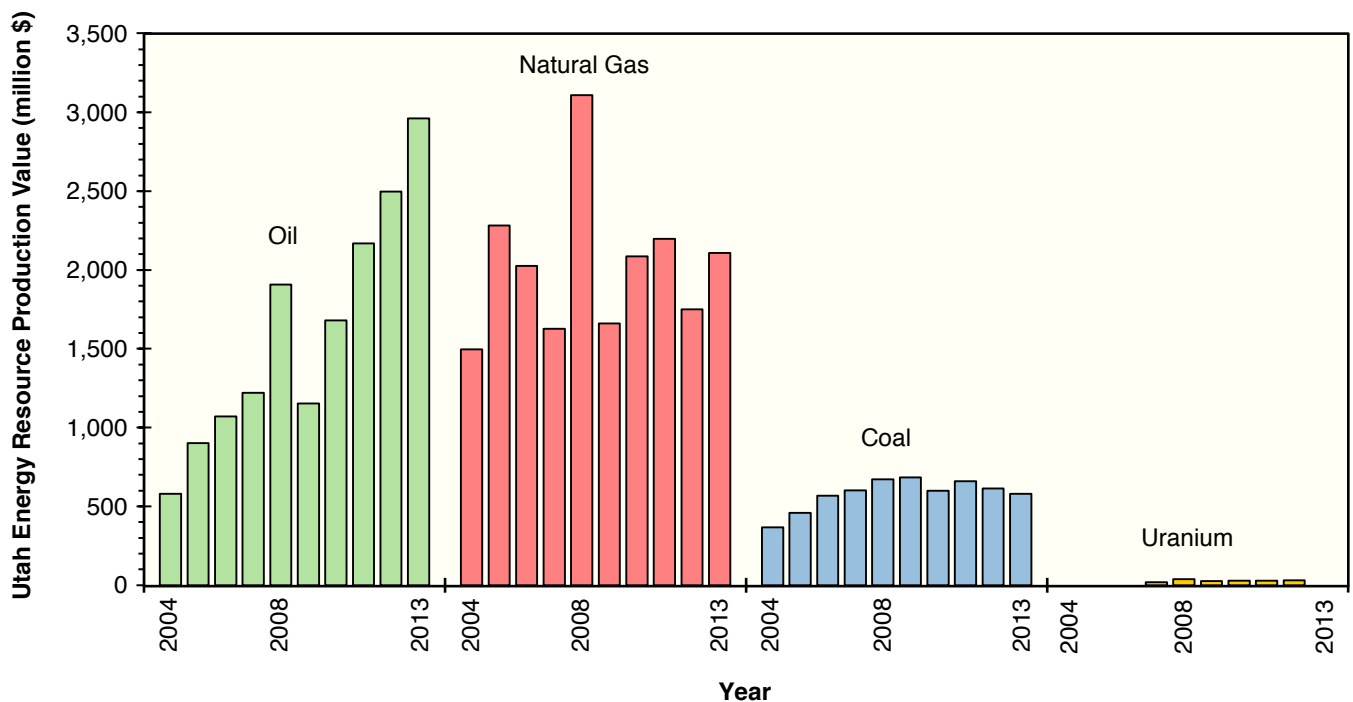


Figure 2. Annual value of Utah energy resource production in nominal dollars, by industry sector, 2004–2013. Data compiled by the Utah Geological Survey.

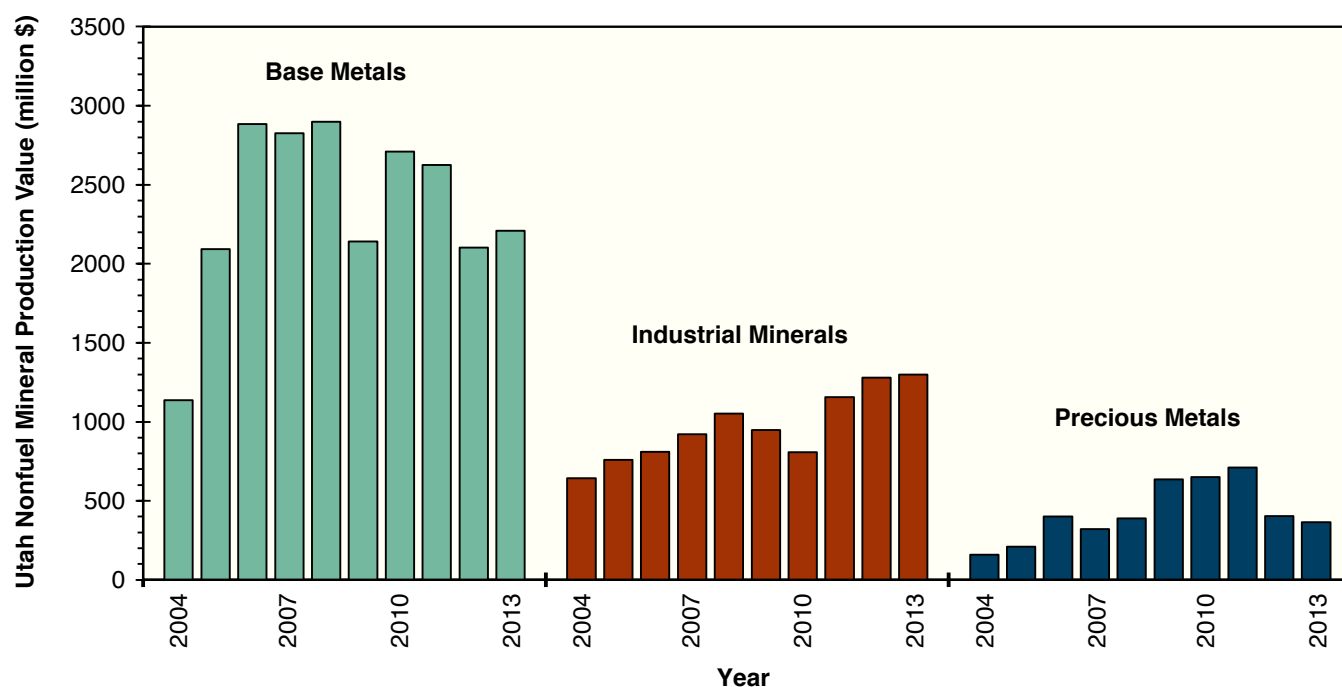


Figure 3. Annual value of Utah nonfuel mineral production in nominal dollars, by industry sector, 2004–2013. Data compiled by the Utah Geological Survey.

Table 1. Utah nonfuel mineral and energy resource production values in nominal dollars, by industry sector, 2004–2013. Values are in millions.

Year	Base Metals	Industrial Minerals	Precious Metals	Coal	Uranium	Oil	Gas	Total Value
2004	\$1136	\$643	\$158	\$367	\$0	\$580	\$1495	\$4379
2005	\$2093	\$759	\$209	\$459	\$0	\$900	\$2283	\$6703
2006	\$2885	\$811	\$400	\$569	\$0	\$1070	\$2025	\$7760
2007	\$2827	\$921	\$322	\$601	\$20	\$1221	\$1628	\$7540
2008	\$2900	\$1053	\$390	\$672	\$39	\$1908	\$3109	\$10071
2009	\$2142	\$949	\$635	\$684	\$27	\$1152	\$1661	\$7250
2010	\$2710	\$808	\$651	\$599	\$28	\$1679	\$2087	\$8562
2011	\$2625	\$1156	\$711	\$660	\$29	\$2169	\$2198	\$9548
2012	\$2104*	\$1280*	\$403*	\$614*	\$31	\$2500	\$1750*	\$8682*
2013**	\$2210	\$1300	\$365	\$579	\$0	\$2961	\$2108	\$9523

Notes: Gas includes natural gas and natural gas liquids; sulfuric acid was added to industrial minerals in 2011.

*Revised data

**Estimated data

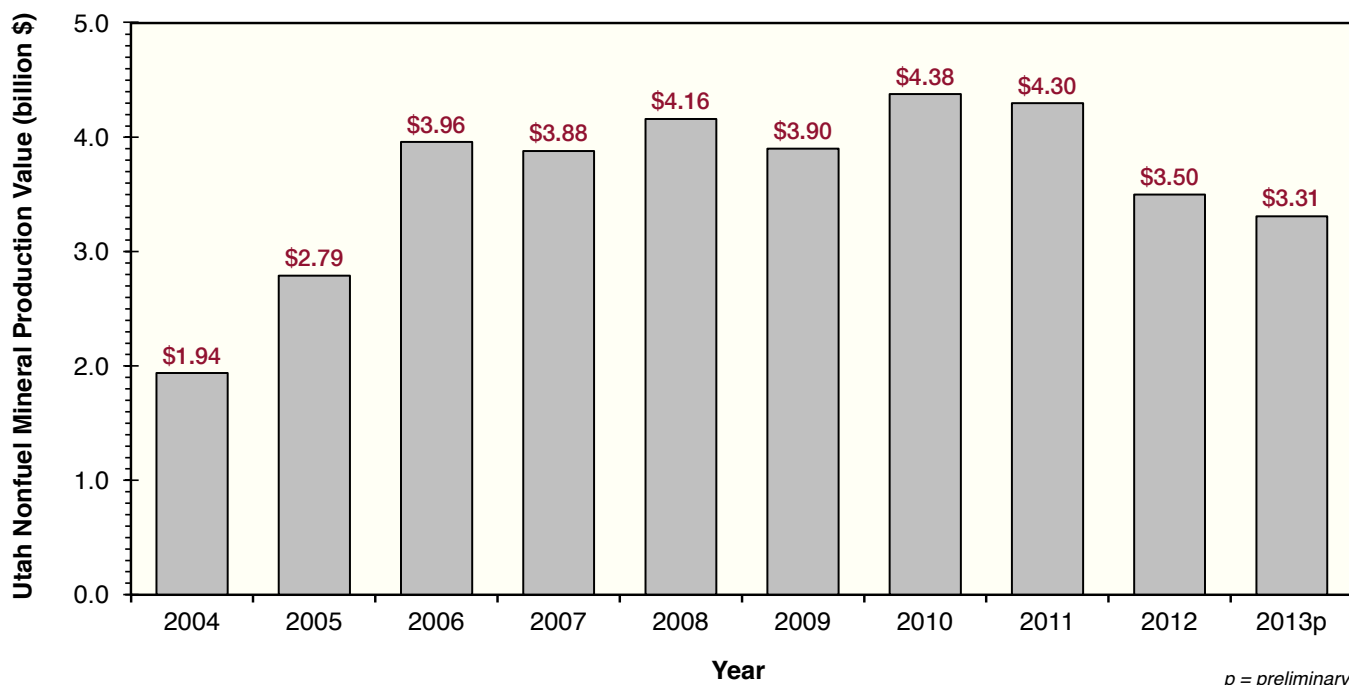


Figure 4. Annual value of Utah nonfuel mineral production in nominal dollars, 2004–2013. Source: U.S. Geological Survey (USGS, 2014a).

Mineral exploration and development declined again in 2013 relative to 2012; the primary exploration targets were potash, phosphate, and gold. Commodity price indices peaked in July 2008, collapsed later that year, rebounded gradually to reach a new peak in 2011, and have subsequently declined in 2012 and 2013.

Less than 2000 new unpatented mining claims were filed in Utah in 2013; the declining number of claims is likely related to slumping metal prices. Beaver (copper), Millard (gold, copper), San Juan (uranium, copper), Grand (uranium, vanadium), Juab (copper, gold, silver), and Box Elder (gold, silver) were the most active counties during 2013 with each recording more than 150 new claims. At the end of 2013, the Bureau of Land Management (BLM) had a total of 19,487 active unpatented mining claims in Utah, which is the lowest number since 2006 (Opie Abeyta, Utah BLM, written communication, April 2014).

The Utah School and Institutional Trust Lands Administration (SITLA), which manages about 4.4 million acres of state-owned lands in Utah, celebrates its twentieth year as an independent agency in 2014. SITLA issued new leases and/or contracts on 62 tracts in 2013, which was down 33% from 2012. These leases were issued for the following commodities: metalliferous (33), sand & gravel (11), phosphate (5), bituminous sand (3), geothermal (2), building stone (2), limestone (2), potash (1), gilsonite (1), coal (1), gemstone/fossil (1), and gypsum (1) (Jerry Mansfield, SITLA, written communication, April 2013).

The Utah DOGM approved four new large mine permits, 13 small mine permits, and nine exploration notices of intent (NOI) in 2013. All of the large mine permits, 10 of the 13 small mine permits and three of the nine NOIs were for industrial minerals with the remainder of the permits for metals. Most of the industrial mineral permits were for construction materials (Doug Burnett, DOGM, written communication, April 2014).

National Rankings

Preliminary data show Utah ranked 7th nationally in 2013 for the value of nonfuel mineral production, accounting for about 4.5% of the United States total. Utah remained among the top 10 nonfuel mineral-producing states during the past decade (USGS, 2014a). The USGS data also show that Utah nonfuel mineral production value decreased in 2013 to an estimated \$3.3 billion, which is significantly less than the record \$4.4 billion set in 2010 (figure 4). The value of Utah nonfuel mineral production increased between 2004 and 2011 despite the national economic downturn in 2008, but has decreased since 2012 due primarily to declining base and precious metal prices. Utah remains the only U.S. state to produce magnesium metal, beryllium concentrate, and gilsonite. In the 2013 Fraser Institute annual survey of mining companies (Wilson and Cervantes, 2014), Utah was ranked as the 15th most favorable state/nation (87th percentile) out of the 112 international jurisdictions included in the survey in terms of overall investment attractiveness with regard to mining. The investment attractiveness index is a combination of a region's geologic favorability and government policies toward exploration and

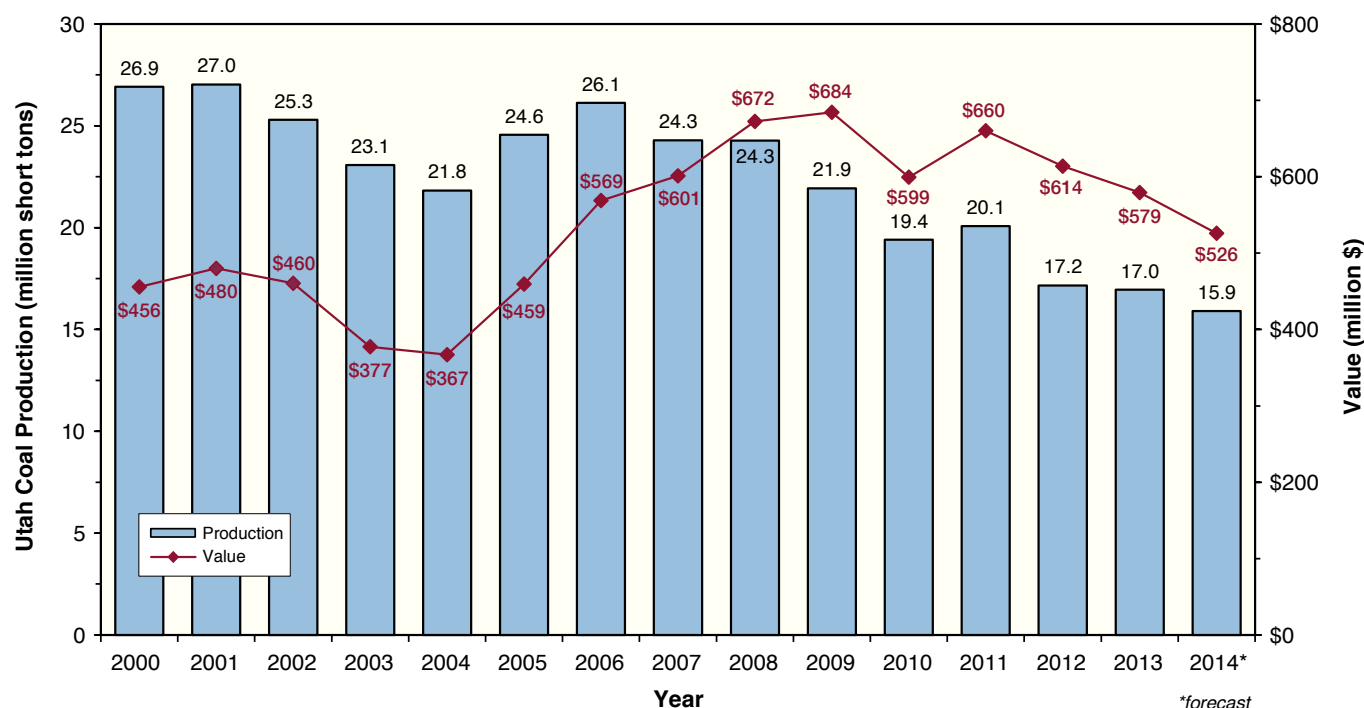


Figure 5. Utah annual coal production and value in nominal dollars, 2000–2014.

development. Compared to other states Utah ranked 14th for 2013 coal production (U.S. EIA, 2014a), 11th for 2013 oil production (U.S. EIA, 2014b), and 11th (2012 ranking) for 2012 the natural gas production (U.S. EIA, 2014c).

Outlook for 2014

Of the nonfuel mineral-producing companies surveyed for this report, 50% project duplicating 2013 production in 2014, 36% plan to increase production, and 14% anticipate less production. The massive April 2013 landslide of approximately 149 million short tons (st) of waste rock from the northeast highwall into the bottom of KUC's Bingham Canyon open pit copper-gold-molybdenum-silver mine will continue to have significant negative consequences on Utah nonfuel mineral production in 2014 and 2015. Nonetheless, Bingham is expected to produce more metal in the upcoming year than in 2013. Commodity prices in 2014 seem to have stabilized from the 2012–13 price slumps. Increasing metal production and stable commodity prices should slightly increase Utah nonfuel mineral production value in 2014. Improvements at the CML Metals Corporation iron ore concentrator in early 2014 are expected to increase production of iron ore concentrate by 25%, to more than 2 million st annually. Low uranium prices resulted in a halt to all production from Energy Fuels uranium mining operations in Utah in late 2012, and will consequently result in the loss of byproduct vanadium production as well in 2014. Uranium and vanadium production from Utah mines is not expected to resume until uranium prices increase. Production of potassium chloride is expected to decrease, while production of the higher value potassium sulfate is expected

to increase. Other industrial minerals production will probably remain stable or perhaps increase slightly with an improving housing and construction economy. Nonfuel mineral exploration activities in Utah are expected to slightly increase during 2014. Most nonfuel exploration activities planned in 2014 are focused on potash, phosphate, copper, and gold.

Utah coal production is expected to decrease in 2014 to 15.9 million st, while prices should remain steady (figure 5; table 2). Continued coal production declines are mostly demand related. High crude oil prices are expected to spur more development, particularly in Duchesne County, and crude oil production should continue to increase in the next few years. Meanwhile, the price for natural gas has been recovering slowly from a low in April 2012, limiting the economic incentive for expanded development.

BASE AND PRECIOUS METALS

Production and Values

Base and precious metals produced in Utah during 2013 have an estimated value of \$2.57 billion, which accounts for 66% of the annual value of nonfuel minerals produced in Utah. Overall, base and precious metal production values increased 2.7% from 2012. The estimated base metal production value in 2013 was \$2.21 billion, which accounted for 57% of the annual value of Utah nonfuel mineral production (figure 3; table 1). Utah's base metal production value increased by 5% from 2012 because of an increase in the production of copper.

Table 2. Coal production in Utah by coal mine, 2009–2014.

Company	Mine	County	Coalfield	2009	2010	2011	2012	2013	2014*
				thousand short tons					
Canyon Fuel Company, LLC - Bowie Resources Partners, LLC ¹	Dugout Canyon	Carbon	Book Cliffs	3,291	2,307	2,395	1,588	561	600
	Skyline #3	Carbon	Wasatch Plateau	2,910	3,050	2,950	1,954	3,135	3,100
	SUFCO	Sevier	Wasatch Plateau	6,748	6,398	6,498	5,651	5,959	6,300
CONSOL Energy	Emery	Emery	Emery	1,238	999	–	–	4	–
Castle Valley Mining, LLC - Rhino Resource Partners, LP ²	Castle Valley #4	Emery	Wasatch Plateau	651	–	592	1,004	875	900
Energy West Mining Co. - PacifiCorp	Deer Creek	Emery	Wasatch Plateau	3,833	2,954	3,143	3,295	2,785	2,000
Hidden Splendor Resources, Inc. - America West Resources, Inc.	Horizon	Carbon	Wasatch Plateau	194	270	370	210	–	–
West Ridge Resources, Inc. - UtahAmerican Energy, Inc. - Murray Energy Corp.	West Ridge	Carbon	Book Cliffs	3,063	3,355	3,566	2,579	2,629	2,000
UtahAmerican Energy, Inc. - Murray Energy Corp.	Lila Canyon	Emery	Book Cliffs	–	72	157	304	257	250
Alton Coal Development, LLC	Coal Hollow	Kane	Alton	–	–	403	570	747	750
Total				21,928	19,405	20,074	17,155	16,953	15,900

Source: Utah Geological Survey coal company questionnaires

*Forecast

¹Owned by Arch Coal until summer 2013²Owned by C.W. Mining (Co-op) until summer 2010, mine formerly called Bear Canyon

The base metals, in decreasing order of 2013 value, are copper (75%), magnesium (12%), molybdenum (6%), iron (6%), and beryllium (1%).

Precious metal production value for Utah in 2013 is estimated at \$365 million, or 9% of the value of nonfuel minerals produced in Utah, and is distributed between gold (80%) and silver (20%) (figure 3; table 1). Precious metal production value decreased by 10% from 2012 to 2013, due to significantly lower gold and silver prices.

Most Utah copper, gold, and silver, and all of the molybdenum, is produced from the KUC Bingham Canyon mine,

which is located about 20 mi southwest of Salt Lake City in Salt Lake County (figure 6). The combined value of metals produced by KUC in 2013 is estimated at \$2.07 billion, which is a 4% increase from 2012 and accounts for 53% of the value of nonfuel minerals produced in Utah. Bingham Canyon mine was the second largest copper producer and fifth largest molybdenum producer in the U.S. during 2013.

Copper

In 2013, copper was the largest contributor to the value of nonfuel minerals in Utah, with an estimated value of \$1.66 billion, which is 21% more than its value in 2012. The

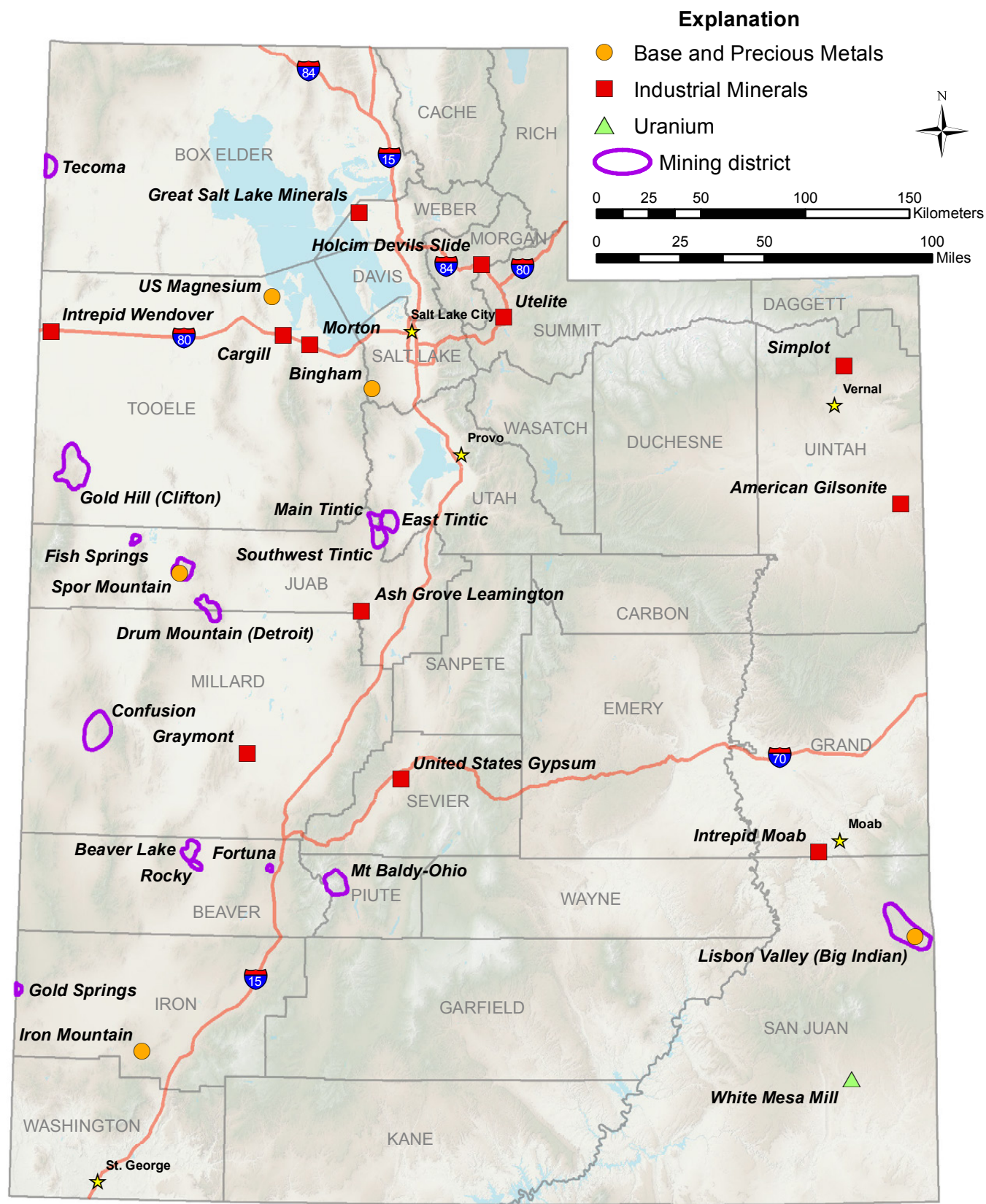


Figure 6. Base and precious metals, selected industrial minerals, and uranium production and development activity locations in Utah during 2013.

KUC Bingham Canyon mine produced most of this copper, with their 2013 production amounting to 232,000 st, which is 52,700 st more than their production in 2012 (Rio Tinto, 2014). The average copper price decreased about 7% from 2012 to \$3.40/lb (USGS, 2014a), and KUC production for 2013 has an estimated value of \$1.58 billion, which is an increase of about 20% from 2012.

Lisbon Valley Mining Company operates a copper mine and processing facility about 30 mi southeast of Moab in San Juan County (figure 6). About 7850 st of copper was produced by the company in 2013, which is significantly more than in 2012. The 2013 production has an estimated value of \$53 million at the 2013 average copper price (USGS, 2014a). CS Mining produced about 3000 st of copper in 2013 from its Hidden Treasure mine in Beaver County. Copper is combined with a number of metals to create alloys for a wide variety of applications, and is used to produce a wide range of products including electrical wiring, electronic components, and pipe for plumbing, refrigeration, and heating systems.

Magnesium

U.S. Magnesium, LLC, is the only facility producing magnesium from a primary source in the United States and is located about 60 mi west of Salt Lake City at Rowley in Tooele County (figure 6). Magnesium chloride concentrate is produced from Great Salt Lake brines through evaporation and converted to magnesium metal by an electrolytic process. The USGS (2014a) reports that annual magnesium production capacity at the U.S. Magnesium plant is 70,000 st. The price for magnesium metal decreased slightly from 2012, averaging \$2.13/lb in 2013 (USGS, 2014a). Assuming the plant operated at full capacity, Utah 2013 magnesium production has an estimated value of \$298 million, which is about 3% less than in 2012. This valuation makes magnesium the second most valuable base metal produced in Utah during 2013. Significant quantities of U.S. Magnesium's production are used by a nearby plant, operated by Allegheny Technologies Inc., to produce titanium sponge. Nationally, other markets for magnesium include use as a constituent of aluminum-based alloys, structural use in castings and wrought products, desulfurization of iron and steel, and other uses (USGS, 2014a).

Molybdenum

Utah molybdenum production in 2013 came solely from the KUC Bingham Canyon mine, and was recovered as a by-product from the copper operation. Approximately 6300 st of molybdenum were produced in 2013, which is 39% less than in 2012 (Rio Tinto, 2014). The average price of molybdenum decreased by 19% during 2013 to \$10.31/lb (USGS, 2014a). At the 2013 average price, Utah molybdenum production has an estimated value of \$131 million, which is 50% less than in 2012 and consistent with declining production and lower prices. Molybdenum ranked third as a contributor to Utah base metal values in 2013. In 2013, molybdenum concentrate

in the U.S. was produced by 11 mines, as either a primary product or byproduct, and was valued at about \$1.4 billion. Molybdenum is primarily used in alloys with other metals by iron, steel, and other producers that account for about 72% of the molybdenum consumed (USGS, 2014a).

Iron Ore

Iron ore in Utah is mostly produced by CML Metals, Inc., from their Iron Mountain project, which is a redevelopment of the Comstock-Mountain Lion iron mine located about 19 mi west of Cedar City in Iron County (figure 6). In 2013, CML Metals produced 1.4 million st of concentrate at 65% iron, which has an estimated value of \$125 million at an average price of \$89.58/st (USGS, 2014a). CML Metals produced significantly more iron ore concentrate in 2013 than in 2012, due to improvements in concentrator operations (CML Metals, 2014). Iron ore production ranks fourth in contribution to 2013 Utah base metal production value. Iron ore from the Iron Mountain project is transported by rail to a port in southern California and shipped overseas. In addition, CS Mining produced 14,000 st of magnetite in 2013 from its Hidden Treasure mine in Beaver County.

Beryllium

Utah remains the United States' sole producer of beryllium ore from the mineral bertrandite [$\text{Be}_4\text{Si}_2\text{O}_7(\text{OH})_2$]. Materion Natural Resources, Inc., mines bertrandite from the Spor Mountain area about 42 mi northwest of Delta in Juab County (figure 6). Materion operates a mill 11 mi north of Delta in Millard County, which is the nation's sole source of beryllium concentrate. Bertrandite ore and imported beryl are processed at the mill into beryllium hydroxide. Materion's parent company (Materion Corporation) operates a refinery and finishing plant in Ohio where the beryllium hydroxide concentrate is shipped and converted to beryllium-copper master alloy, metal, and oxide (USGS, 2014a). About 110,000 st of bertrandite ore was mined in 2013 from the Topaz mine at Spor Mountain. Beryllium concentrate production from Utah in 2013 is estimated to be 225 st, which is slightly less than in 2012, with a value of about \$19.7 million. The average beryllium price for 2013 (\$209/lb) was slightly higher than in 2012 (USGS, 2014a), which resulted in an increase of about 1% in value over 2012. Beryllium ranked fifth as a contributor to 2013 Utah base metal values. Beryllium is a specialty metal used in various telecommunications and consumer electronics products, defense-related applications, industrial components, commercial aerospace applications, appliances, automotive electronics, energy applications, medical devices, and other uses.

Gold

In 2013, approximately 207,400 troy ounces (oz) of gold were produced in Utah (Rio Tinto, 2014), which was about a 3% increase from 2012. Most of the gold was from the KUC

Table 3. Miscellaneous metal exploration projects in Utah, 2013.

Property	Commodity	District	County	Company	Progress
Blair Project	Silver-Gold	Antelope Range	Iron	Arnevt Resources Inc. (Tuvera Exploration Inc.)	State section acquired and unpatented claims staked
Southwest Property	Polymetallic	Bingham	Salt Lake - Tooele	Grand Central Silver Mines, Inc.	Sold patented claims to Kennecott to Utah Copper
Bingham	Copper	Bingham	Salt Lake	Kennecott Utah Copper Company	Ongoing deep, near-mine drilling
Cave Mine	Polymetallic	Bradshaw	Beaver	Grand Central Silver Mines, Inc.	Integration of mapping, sampling, and geophysics
Drum Mtn.	Polymetallic	Drum Mountains	Juab - Millard	Freeport-McMoran Exploration Corp.	Acquired large fee, state, and federal land positions
Wildcat	Gold-Silver	Drum Mountains	Juab	Renaissance Gold Inc.	Newmont drilled 16 RC holes, but dropped out
Crypto (West Desert)	Polymetallic	Fish Springs	Juab	Lithic Resources Ltd. (InZinc Mining Ltd.)	NI 43-101* completed and PEA** pending
Fortuna North	Gold-Silver	Fortuna	Beaver	Kinross Gold Corp.	Acquired ground, completed 17 holes
Kiewit Deposit	Gold-Silver	Gold Hill	Tooele	Desert Hawk Gold Corp.	Permitted open pit, heap-leach operation
Dutch Mountain	Gold-Silver	Gold Hill	Tooele	Newmont USA Ltd.	Staked about 700 unpatented claims
Jumbo	Gold-Silver	Gold Springs	Iron	High Desert Gold Corp. (TriMetals Mining Inc.)	12 holes and NI 43-101* completed
Goldstrike	Gold-Silver	Goldstrike	Washington	Cadillac Mining Corporation	Developing the Hamburg Extension deposit
Keg	Polymetallic	Keg	Juab	Inland Explorations Ltd.	Integration of mapping, sampling, and geophysics
Kings Canyon	Gold	Kings Canyon	Millard	Pine Cliff Energy Ltd.	NI 43-101* and second phase of drilling completed
Thompson Knoll	Polymetallic	Kings Canyon	Millard	Inland Explorations Ltd.	Integration of mapping, sampling, and geophysics
East Canyon	Polymetallic	Lucin	Box Elder	Arnevt Resources Inc. (Tuvera Exploration Inc.)	NI 43-101* completed
North Lucin	Gold-Silver	Lucin	Box Elder	Newmont USA Ltd.	Staked about 300 unpatented claims
Deer Trail	Polymetallic	Mount Baldy	Piute	Western Pacific Resources Corp.	Property acquired and NI 43-101* completed
Big Hill	Copper	Tintic East	Utah - Juab	Kennecott Exploration Company	Evaluating drill results, more holes planned
SWT Porphyry	Copper	Tintic Southwest	Juab	Freeport-McMoran Exploration Corp.	Evaluating drill results
Spor Mountain Mine	Beryllium	Spor Mountain	Juab	Materion Corp	Significant expansion of Be production capacity
Spor Mountain Project	Rare Metals	Spor Mountain	Juab	Avalon Rare Metals Inc.	Completed four holes totaling 4054 ft
TUG	Gold-Silver	Tecoma	Box Elder	West Kirkland Mining Inc.	NI 43-101* and six metallurgical holes done

*An NI 43-101 is a Canadian National Instrument technical report prepared to a codified set of rules for the public reporting of mineral exploration and development data on properties operated by companies listed on Canadian stock exchanges.

**Preliminary Economic Assessment

Bingham Canyon mine, where it is recovered as a byproduct from the copper ore. About 400 troy oz of gold came from residual leaching of existing heaps at the KUC Barneys Canyon mine, which ceased active mining in 2001 after ore exhaustion, and is located 2.5 mi north of the Bingham Canyon operation. The average gold price in 2013 was \$1400/troy oz, which is 16% less than the 2012 price (USGS, 2014a). Utah 2013 gold production at the 2013 average price has a value of \$290 million, which is 14% less than the 2012 valuation. Small quantities of gold and silver may have been produced by other small Utah mines, but this production is inconsistently reported and would not make a significant impact on the total amount of gold and silver produced in Utah.

Silver

Most of the silver produced in Utah during 2013 came from the KUC Bingham Canyon mine (Rio Tinto, 2014), and was recovered as a byproduct from the copper ore. Total silver production in 2013 was about 3,123,000 troy oz, which is a 47% increase from 2012. In 2013, CS Mining produced approximately 247,000 troy oz of silver from its Hidden Treasure mine in Beaver County. The average silver price in 2013 was \$23.80/troy oz (USGS, 2014a), which is a 24% decrease from the 2012 average price. Utah silver production during 2013 at the 2013 average price has a value of \$74 million, which is 12% more than the 2012 valuation.

Exploration and Development Activity

The information in this section is largely from mining company websites, press releases, and the UGS annual industry survey of mine and quarry operators. Exploration and development information was also obtained from the DOGM website (<http://linux1.ogm.utah.gov/WebStuff/wwwroot/minerals/mineralsfilesbypermitinfo.php>). The location of selected exploration areas in 2013 is shown in figure 6.

The most significant event of 2013 for the Utah metal mining industry was the massive pit wall failure at Bingham on April 10. This was the largest landslide in mining history. In spite of this, Bingham did not actually incur decreased metal production in 2013, primarily because 2012 was an off year for the mine. Bingham remained the second largest copper producer in the U.S. in 2013, but fell to fifth in molybdenum production.

For the second consecutive year, Utah metal production values declined in 2013 as copper, molybdenum, gold, silver, and magnesium prices fell. However, production from the Lisbon Valley sediment-hosted copper solvent extraction-electrowinning operation increased. The CML Metals (Iron Mountain) iron mine and the CS Mining (Hidden Treasure) copper mine near Milford both continued shipping concentrates in 2013. Overall, metallic mineral exploration activity was down in 2013. The significant known Utah base and pre-

cious metal properties are shown in figure 6 and summarized in table 3.

Bingham Canyon

The single most significant event of 2013 for the Utah metal mining industry was the massive pit wall failures at the Bingham Canyon open pit mine (figure 6) on April 10, which brought about 165 million st of waste into the bottom of the open pit (Cover and figure 7) (Pankow and others, 2014). Two landslides occurred from the northeast corner of the open pit on April 10, the first at 9:30 p.m. was larger (nearly 100 million st) and the second followed a little over an hour and a half later at 11:05 p.m. The second slide was followed 11 minutes later at 11:16 p.m. by a small, shallow, induced earthquake (~2.5 magnitude) beneath the mine and a series of 15 smaller aftershocks over the next six days. The slides were estimated to have reached speeds in excess of 70 mph (Pankow and others, 2014).

Most notably, the Manefay slides resulted in no injuries or deaths, but the face of the mine was significantly changed and hundreds of millions of dollars of damage was done to the operation. Rio Tinto reported pre-tax charges in 2013 relating to the slide of \$547 million. Despite the slide, metal production was maintained and slightly exceeded 2012 output.

A sophisticated network of geotechnical monitors showed instability at the mine beginning in November 2012. The instability markedly increased in February 2013, which prompted the dismantling and relocation of the Bingham visitor center in late March and early April. Notably, subsequent events would show that the visitor center had been located on the main body of the slide. When monitors showed increasing displacement, which reached a rate of about 2 inches per day, all employees were evacuated from the mine at 11 a.m. prior to the slide, and a press release was issued at 2:38 p.m. that a slide was anticipated.

Despite these commendable efforts, the slide resulted in significant damage to both the mine infrastructure (including the main haul road) and, unexpectedly, the fleet of excavation equipment. The damages to the fleet included 3 of 13 shovels, 14 of 100 haul trucks, and ancillary equipment including drills, bulldozers, and graders (given that haul trucks cost approximately \$6 million and shovels about \$30 million each, the equipment damages were significant).

The headwall of Bingham's Manefay slide is 1150 ft high and the slide is 9840 ft long with a vertical displacement of 2975 ft. The slide failed mainly along the moderately north-northwest-dipping (20–50°) Manefay series beds at the base of the Upper Bingham Mine Formation (Upper Pennsylvanian). The slide was larger than had been anticipated. More importantly, unlike previous failures elsewhere in the pit that acted like rock falls and slumps, this slide acted far more fluidly, and

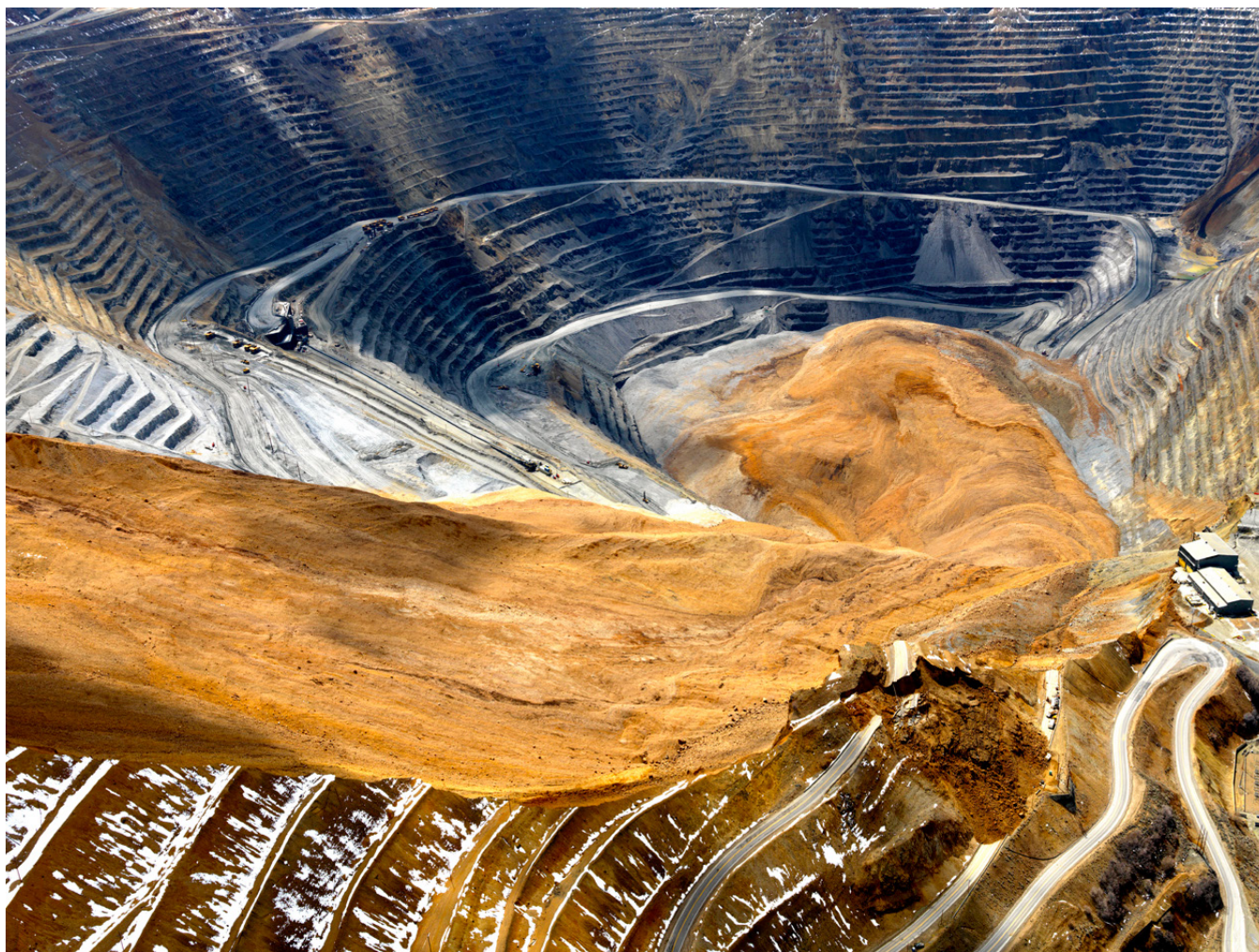


Figure 7. Aerial view of the Manefay landslide at the Bingham Canyon open pit copper mine. The slip plane in the Manefay series beds at the base of the Upper Bingham Mine Formation is shown in the left middle ground. Some of the damage to the paved mine access road and the haul truck shop (large building on the edge of the slide) are apparent in the foreground. The undamaged in-pit crusher can be seen in the upper left and the underground conveyor from the crusher to the mill passes directly under the slide toward the lower left corner of this image, but was also left intact. Photo courtesy of Kennecott Utah Copper.

is more properly described as a rock avalanche (Pankow and others, 2014). Consequently, the slide advanced much farther across the pit bottom than anticipated, and damaged the excavation equipment parked in the southwest corner of the pit.

The first priority after the slide was to assess the situation and develop a plan to stabilize the headwall of the slide so it was safe to work under. Excavation from the higher parts of the southwest corner of the pit resumed two days after the slide. Because the in-pit crusher and underground ore conveyor were undamaged, ore production resumed 17 days later. The other priority was to re-establish the main haul road in the pit. The new haul road is about $\frac{3}{4}$ mi long, 150 ft wide, and required the removal of 6 million st of material. This track was completed in less than 7 months, largely due to the development and innovative use of more than 20 pieces of remotely operated heavy equipment in areas that were not safe for employees to work. Some of the damaged equipment was

recovered from the slide and has returned to service including five of the 14 damaged haul trucks.

In response to the slide, Kennecott purchased two new shovels, 20 haul trucks, 30 dozers, nine excavators, and three drills. However, about 345, mostly salaried, personnel have been cut. The mine is expected to increase production through 2014 and 2015 and reach full capacity in 2016. Besides financial problems associated with the Manefay slide, Rio Tinto corporate debt, related to the inopportune 2007 acquisition of the Canadian aluminum company Alcan Inc., caused the suspension of work on the molybdenum autoclave project (MAP).

Despite the landslide, Bingham's copper, gold, and silver production was up slightly in 2013 from 2012. However, molybdenum production at Bingham was down significantly (39%) in 2013. Overall, the total gross sales revenue from Bingham

was up about 5% to \$2.05 billion in 2013.

Although KUC's Barneys Canyon gold mine ceased mining in 2001, the operation has continued to recover minor amounts of gold by continued leaching of the old heap leach pads into early 2013 (about 400 ounces). The operation closed in mid-2013 and Barneys Canyon is preparing for final closure and reclamation.

Kennecott Exploration Company continued an aggressive brownfields, near mine exploration drilling program in the Oquirrh Mountains in 2013, prior to the slide. An additional three core holes (including deflections) totaling 2424 ft were finished in the Bingham mine area. Additional holes are planned for 2014 (Russ Franklin, Kennecott Exploration Company, written communication, April 2014).

Iron Springs

The CML mine (formerly the Comstock-Mountain Lion) (figure 6), in Iron County, was acquired by Palladon Iron Corporation in 2005 and restructured into CML Metals Corp. in early 2010. The iron ore occurs as massive magnetite skarn/replacement deposits adjacent to Miocene monzonite laccoliths. Open pit mining began in 2008, but ceased in 2009 due to market volatility and logistical problems. In 2009, Palladon completed a Canadian NI 43-101 compliant resource estimate on the CML deposit showing a resource of 31.35 million st averaging 48.6% iron (SRK Consulting, 2009). CML resumed mining in July 2010 and run-of-mine ore was shipped from the new rail load-out facility at the mine by the Union Pacific Railroad. The concentrator was completed in early 2012 and operated at limited capacity through 2012, due to concentrate dewatering difficulties that continued into 2013. CML mined approximately 1.35 million st in 2013 and is still improving the concentrator efficiency after adding new hyperbaric filter dewatering units. CML hopes these improvements allow them to produce a high-grade (67% iron) concentrate at a rate of 2 million st per year in 2014.

Lisbon Valley Copper

The Lisbon Valley Mining Company operates a sediment-hosted, open-pit, heap leach, solvent extraction and electrowinning (SX-EW) copper operation situated in the Lisbon Valley mining district of San Juan County (figure 6). The company began copper mine development in 2005 with plant construction completed in 2006. Following some startup difficulties, Lisbon Valley Mining Company, LLC, has been operating successfully since 2009. Mine production in 2013 was up about 20% to 15.7 million pounds of copper cathode.

Rocky and Beaver Lake Districts

CS Mining, LLC, controls a series of small copper deposits in the Rocky and Beaver Lake mining districts of Beaver Coun-

ty (figure 6). These properties include six partially delineated prograde copper skarns and a breccia pipe. In 2009, a flotation mill was completed and open pit mining started on the Hidden Treasure copper skarn. The mill began production at 1200 st/d in May 2009 and produced a limited amount of copper concentrate. A separate magnetite concentrate was also produced and sold to a coal wash plant in the fall of 2009. However, the mill achieved less than 20% copper recovery due to the mixed oxide-sulfide nature of the ore and operations were halted near the end of 2009. The mine and mill resumed operation in September 2012. In 2013, 918,000 st of ore and 2,972,000 st waste were mined from the Hidden Treasure mine. Although copper recovery remains limited, the ore yielded 13,202 st of copper concentrate (22.4% copper and 18.7 ounces/ton silver), which contained 5.9 million pounds of copper and 247,000 ounces of silver. The copper concentrates are shipped by truck to the KUC smelter at Magna, Utah. CS Mining plans to add a new solvent extraction—electrowinning plant to reprocess the flotation mill tailings and recover additional metal from the copper oxides and carbonates. The new plant should significantly increase copper recovery.

Spor Mountain

The Spor Mountain mining district, which is the world's premier beryllium producer, lies on the west flank of the Thomas Range in west-central Juab County (figure 6). An estimated 3 million st of ore with an average 0.2% beryllium has been mined from 10 small- to medium-sized pits in the district since production began in the late 1960s. Materion has proven reserves of about 6.25 million st of bertrandite ore, which at current production rates would support more than 70 years of beryllium hydroxide production. The property also includes another 6.15 million st of bertrandite ore in undeveloped resources. Materion Corporation significantly increased beryllium production in 2013 to 110,670 st of ore from about 80,000 st in recent years.

Avalon Rare Metals controls 383 unpatented lode claims (7900 acres) on an adjacent Spor Mountain rare-metal prospect. Geologic and ground magnetic surveys were completed in 2011. In 2012, Avalon also recovered 4055 ft of core from four drill holes at Spor Mountain. All four holes reportedly encountered intense alteration, brecciation, and faulting, which are typically found near hydrothermal mineralization.

Drum Mountains

The Drum Mountains (Detroit mining district) remained one of the most competitive metal exploration areas in the state in 2013 (figure 6). Freeport-McMoRan Exploration Corporation acquired 1020 acres of SITLA land, which include about 1000 acres of patented mining claims, and staked an additional 395 unpatented lode claims in the copper-gold area of the old mining district. Freeport-McMoRan has obtained drilling permits and plans to begin drilling in the spring of 2014.

Newmont Mining Corporation signed an earn-in agreement with Renaissance Gold Inc. on the Wildcat sedimentary-rock-hosted gold property in the northern Drum Mountains of Juab County. Newmont completed four reverse circulation holes in 2011 and approximately 12 more holes in 2012 totaling an additional 9025 ft, but abandoned the project in 2013 (Rendy Keaten, Newmont Mining Corporation, written communication, May 2013). Other active companies include Golden Dragon Capital (82 claims), the Steele family (70 claims), CS Mining, LLC (226 claims), and North Exploration, LLC (10 claims), which acquired land positions in the Drum Mountains of Juab and Millard Counties for copper and gold.

Gold Hill District

Clifton Mining Company and Desert Hawk Gold Corp. agreed in 2009 to jointly develop Clifton's mineral properties in the Gold Hill district of western Tooele County (figure 6). Desert Hawk received permits and began construction of a small open pit, heap leach operation at the Kiewit, low-sulfidation, quartz-carbonate-adularia stockwork gold deposit. The Miocene-age Kiewit deposit is believed to contain roughly 1.7 million st of ore with average 1 ppm gold. Desert Hawk is working to expand and better define the resource.

Tecoma District

In 2010, the TUG distal disseminated silver-gold deposit in the Tecoma district of westernmost Box Elder County was optioned by West Kirkland Mining (USA) Ltd. from Newmont (figure 6). The TUG deposit contains a historical, open-pit-able resource of about 1.5 million st averaging 1.71 ppm gold and 100 ppm silver. Recent work has increased the indicated resource size to 4.85 million st, grading 0.84 ppm gold and 40.4 ppm silver. TUG contains an estimated 131,000 ounces of gold and 6.3 million ounces of silver (Evans and others, 2014).

Confusion Range

In 2012, Geomark Exploration Ltd. acquired 100% interest in the 2300-acre Kings Canyon sedimentary rock-hosted gold-silver property in southwestern Millard County (figure 6). The property was explored in the early 1990s, primarily by Crown Resources. It contains several known gold zones. The largest defined resource is in the Crown zone, which contains about 7.9 million st averaging roughly 0.93 ppm gold (Krahulec, 2011). Geomark continued drilling in 2013 to expand and better define the Royal zone resource.

Gold Springs District

The Gold Springs mining district is located near the western margin of Iron County (figure 6). The district contains a small, historical, low-sulfidation, epithermal, gold-silver quartz-adularia-calcite vein/stockwork deposit. High Desert Gold

Corp. controls 6000 acres in the Gold Springs district. In 2013, 12 reverse circulation drill holes were completed in the Jumbo zone. Highlights from this program include 85 ft of 0.97 ppm gold and 45.2 ppm silver. High Desert Gold also announced an updated inferred resource on the Jumbo gold-silver stockwork of 6,984,000 st at 0.74 ppm gold and 15.0 ppm silver using a 0.6 ppm "gold equivalent" cut-off grade (calculated based on a 1:57 gold to silver ratio) (Armitage and Studd, 2013).

Tintic District

Andover Ventures Inc. (assigned into bankruptcy on February 12, 2014) purchased 78.5% of Chief Consolidated Mining Company in 2008. Chief Consolidated's main assets were properties in the East Tintic district, of Utah County (figure 6). Andover subsequently released an indicated resource for the Burgin Extension deposit of 920,000 st at 0.86 ppm gold, 249 ppm silver, 9.3% lead, and 3.5% zinc (Tietz and others, 2011).

Kennecott Exploration Company (KEC), through a joint venture with Andover, acquired a porphyry copper lithocap target near Big Hill in the center of the East Tintic district of Utah County. KEC began work in 2010 by running a magnetotelluric grid, six lines of induced polarization (IP), and a high-resolution aeromagnetic survey along with geologic/alteration mapping and collection of about 200 geochemical samples. Four holes were precollared with reverse circulation, totaling 4311 ft, in 2011 and two of these holes, totaling 5159 ft, were core drilled to completion in 2012 (Russ Franklin, Kennecott Exploration Company, written communication, May 2013). Additional drilling is planned by KEC for early 2014.

In 2007, Quaterra Resources, Inc., acquired about 3200 acres of patented and unpatented mining claims encompassing the Southwest Tintic porphyry copper system in Juab County. The property includes a known historical resource of 400 million st with 0.33% copper and 0.01% molybdenum (Krahulec and Briggs, 2006). In a 2009 joint venture with Quaterra, Freeport-McMoRan Exploration Corporation began an integrated program of geological mapping, geochemical sampling, and geophysical surveying; seven exploration holes were drilled in 2010 and 2011. No additional drilling was undertaken in 2012 or 2013, but Freeport-McMoRan Exploration continues to hold the property.

Deer Trail Mine

The Deer Trail mine is in the Mt. Baldy-Ohio mining district on the east flank of the Tushar Mountains of Piute County (figure 6). Upper Paleozoic and Mesozoic sedimentary strata along the base of the range are unconformably overlain by Oligocene and Miocene flows and tuffs of the Marysvale volcanic field. The mineral deposits in the district show crude overlapping, but consistent vertical zonation with alunite deposits at the top of the mountain above 10,800 ft elevation, small epithermal gold-silver veins containing minor base

metals above 9200 ft, and polymetallic vein and replacement deposits below 9200 ft. Most of the production in the district (about 80%) comes from precious-metal-rich, polymetallic replacement ores in the Permian Toroweap Formation at the Deer Trail mine near the base of east face of the mountain. Historical assays of Deer Trail ore run average 3.43 ppm gold, 515 ppm silver, 12% zinc, and 5% lead.

The Deer Trail mine was acquired by Western Pacific Resources Corp. in 2013. Underground sampling of the old workings confirmed the historical assays with highlights including a 5-ft channel sample in the upper Deer Trail mine with 20.8 ppm gold and 163 ppm silver (oxide) and a 1.75-ft channel sample in the lower Deer Trail mine with 164.5 ppm gold, 8090 ppm silver, 2.51% lead, 3.54% zinc, and 0.33% copper (sulfide). Western Pacific also prepared a National Instrument (NI) 43-101 compliant resource evaluation for the Deer Trail mine (Martin, 2013). Between 1975 and 1995, the Deer Trail mine area was explored by a succession of major mining companies, including Phelps Dodge Corporation, Duval Corporation, Noranda Exploration, Inc., Goldfields Mining Corporation, Cominco American, Inc., Battle Mountain Gold Company, LAC Minerals Ltd., and American Barrick Resources, Inc. (Martin, 2013).

Fish Springs District

In 2005, Lithic Resources Ltd. acquired the Crypto zinc-iron \pm copper \pm indium skarn in the Fish Springs mining district of western Juab County (figure 6). In 2009, Lithic completed a 33,000-ft core drilling program and defined two new mineral resources (indicated and inferred) on a shallow oxide zone that included 2.0 million st with an average 8.73% zinc, 0.38% copper, and 14.82 ppm indium, as well as a deep sulfide zone that contains 9.6 million st with an average 7.56% zinc, 0.41% copper, and 46.82 ppm indium. Metallurgical studies of the sulfide resource show the indium is contained in sphalerite and is recoverable (Nilsson and others, 2010). A new preliminary economic assessment is planned for early 2014.

Fortuna District

In 2012, Kinross Gold USA, Inc., staked 305 claims in the Fortuna mining district of Beaver County (figure 6). The Fortuna district includes Miocene low-sulfidation, epithermal, gold-silver quartz-adularia-calcite veins. Kinross also acquired a previously filed block of 25 lode claims and a block of patented mining claims covering an additional 260 acres to the south. Kinross completed 17 holes in 2013.

INDUSTRIAL MINERALS

Production and Values

Industrial mineral production in Utah during 2013 had an estimated value of \$1.3 billion, which was 34% of the annual

value of nonfuel minerals produced in Utah (figure 3; table 1). Industrial mineral production value increased slightly from 2012 due to continued high prices and production for some commodities.

The largest overall contributors to the 2013 value of Utah industrial minerals production were the brine-derived products of potash, salt, and magnesium chloride. These products had a combined value of \$485 million, which is a 10% increase from 2012 and accounts for 37% of total value of Utah industrial mineral production in 2013. The sand and gravel, crushed stone (including limestone and dolomite), and dimension stone commodity group was the second-largest contributor to the value of industrial minerals production at \$237 million. This commodity group accounted for 18% of total industrial mineral value in 2013, and was 3% more than the 2012 production value. The third-largest contribution to the value of industrial minerals production came from the Portland cement and lime product group, which had a combined value of \$180 million that accounted for 14% of total industrial mineral value in 2013, and was a 7% decrease in value from 2012. These three commodity groups contributed 69% of the total value of industrial minerals produced in Utah during 2013. The remainder came from, in decreasing order of value, sulfuric acid, phosphate, gilsonite, clay, expanded shale, and gypsum.

Potash, Salt, and Magnesium Chloride

The brine-derived commodities produced from Great Salt Lake include, in descending order of production, salt, magnesium chloride, and potash (in the form of potassium sulfate). Potash, in the form of potassium chloride along with significant amounts of magnesium chloride and lesser amounts of salt, was also produced by operations in other parts of the state.

Potash production in Utah exceeded 455,000 st in 2013, and was the largest contributor to the value of the brine-derived commodity group. The 2013 value of potash produced in Utah was approximately \$236 million, which was a decrease of about 6% from 2012. The declining value was due to a decrease in the production of potassium sulfate and the price of potassium chloride. Potassium sulfate has a significantly higher market value than potassium chloride. Great Salt Lake Minerals Corporation produces potassium sulfate, whereas Intrepid Potash-Wendover and Intrepid Potash-Moab produce potassium chloride (figure 6).

Although Utah salt production in 2013 increased only slightly to 3.23 million st, the value of the salt increased by 11% to \$172 million, due to a higher market price. Some 82% of this salt was produced from Great Salt Lake brine by three operators, namely, Great Salt Lake Minerals Corp., Cargill Salt Co., and Morton International (in descending production order) (figure 6). The remaining 18% came from Redmond Minerals, Inc., near Redmond in Sanpete County, Intrepid Potash-Wendover near Wendover in Tooele County, and

Intrepid Potash-Moab near Moab in Grand County (in descending production order).

In 2013, Magnesium chloride production in Utah decreased by 10% to 770,000 st, with a production value of about \$77 million. Most of the magnesium chloride was produced by Great Salt Lake Minerals Corporation on the east side of Great Salt Lake and Intrepid Potash-Wendover. Utah Minerals Recovery, LLC, also produced a small amount of magnesium chloride in 2013 at their Knolls facility about 28 mi east of Wendover.

Sand and Gravel, Crushed Stone, and Dimension Stone

Sand and gravel, crushed stone, and dimension stone are produced by numerous private, county, state, and federal entities. Given the numerous producers of this commodity group, it was impractical for the UGS to send annual production surveys to all of the producing entities. However, the UGS does compile data from selected operators to track these commodities, and uses USGS data for production and value figures. During 2013, approximately 26.9 million st of sand and gravel with a value of \$182 million was produced in Utah (USGS, 2014b). About 7.65 million st of crushed stone with a value of \$54.6 million was also produced (USGS, 2014b), as well as an estimated 9000 st of dimension stone with a value of \$0.7 million. The total 2013 production value for the commodity group increased by 3% to approximately \$237 million. The increased value resulted from a slight increase in sand and gravel production and prices.

Portland Cement, Lime, and Limestone

Together, Ash Grove Cement Co. and Holcim, Inc., produced more than one million st of Portland cement in Utah during 2013, with an estimated value of \$86 million. Ash Grove Cement Co. operates the Leamington quarry and plant east of Leamington in Juab County, whereas Holcim Inc. operates the Devils Slide quarry and plant east of Morgan in Morgan County (figure 6). In 2013, Portland cement production decreased by 24% from 2012, resulting in a significant value decrease for 2013 as well. The combined annual capacity of the companies is about 1.5 million st. Besides limestone, the Ash Grove and Holcim mines also produce small amounts of sandstone, clay, and shale, which are minor feedstock for their cement plants.

During 2013, Graymont Western U.S., Inc., was the sole producer of lime in Utah. In the past, Lhoist North America produced dolomitic lime, but their quarry and plant in Tooele County have been idle since 2008. Lime production increased approximately 23% from 2012 to 2013. Graymont Western U.S. produces high-calcium quicklime and dolomitic quicklime from their quarry and plant in the Cricket Mountains about 35 mi southwest of Delta in Millard County (figure 6).

The annual production capacity when both plants are in operation is over one million st.

During 2013, 3.6 million st of limestone was produced in Utah. Most of the limestone was from Graymont Western U.S., Inc., Ash Grove Cement Co., and Holcim, Inc. (in decreasing production order). The Cotter Corp. in San Juan County produced a lesser amount of limestone for flue-gas desulfurization at coal-fired power plants. Limestone is primarily used in the manufacture of cement and lime products, with lesser amounts used in various aspects of the construction industry, for flue-gas desulfurization in coal-fired power plants, and as a safety product for the coal mining industry as "rock dust."

Sulfuric Acid

In 2013, the KUC Bingham Canyon mine produced 909,000 st of sulfuric acid (H_2SO_4), which was 14% more than in 2012. The sulfuric acid is a byproduct of the KUC copper-gold-silver smelting process. The UGS estimated sulfuric acid prices averaged about \$140/st in 2013, which gives Utah production an approximate value of \$127 million. Although sulfuric acid has been recovered at the Bingham copper smelter since 1917, the commodity has only recently been included in the UGS production survey. Currently, sulfuric acid is the fourth most valuable industrial mineral produced in Utah. Sulfuric acid is used in the production of fertilizer and by some gold, copper, uranium, and beryllium producers, as well as in chemical manufacturing, power plants, steel companies, farming, and water treatment.

Phosphate

Simplot Phosphates continues to be the only active phosphate producer in Utah. The company phosphate operation is located 12 mi north of Vernal in Uintah County (figure 6). In 2013, the mine produced approximately 3.8 million st of ore, which is slightly less than in 2012. The ore yields about 1.4 million st of phosphate concentrate (P_2O_5) after processing. The concentrate is transported in slurry through a 96 mi underground pipeline to the Simplot fertilizer plant near Rock Springs, Wyoming. More than 95% of the phosphate rock mined in the U.S. was used to manufacture phosphoric acids to make ammonium phosphate fertilizers and animal feed supplements (USGS, 2014a).

Gilsonite

Gilsonite is a shiny, black, solid hydrocarbon that occurs in a swarm of laterally and vertically extensive veins in the Uinta Basin. It has been mined since the late 1880s in Utah and Colorado. In 2013, American Gilsonite Company mined and processed gilsonite at their operation in southeastern Uintah County (figure 6). American Gilsonite Co. produced 64,000 st in 2013, which was 20% less than in 2012. The 2013 production value was about \$72.9 million at an average price



Figure 8. Gypsum mining on the Carmel Formation in the San Rafael Swell, Emery County, Utah.

of \$1139/st on federal leases (Office of Natural Resources Revenue, 2014). Small quantities of gilsonite may have been produced by other small Utah mines, but this production is inconsistently reported and would not make a significant impact on the total amount of gilsonite produced in Utah. Utah is the only place in the world that contains large deposits of gilsonite, and it has been shipped worldwide for use in numerous diverse products including asphalt paving mixes, coatings, inks, paints, and oil and gas well drilling additives (Boden and Tripp, 2012).

Bentonite, Common Clay, and High-Alumina Clay

Production of bentonite, common clay, and high-alumina clay in Utah during 2013 was about 171,000 st, which was 37% less than 2012 production. These commodities were produced by many small and large mines often on an intermittent basis; consequently, production and value figures are rough estimates. Bentonite was produced by Western Clay Co. and Redmond Minerals, Inc., which together produced about 74% of the clay commodity group. Uses for bentonite include well drilling and foundry operations, various civil engineering ap-

plications, and litter-box filler. The largest producers of common clay and high-alumina clay were Interstate Brick Co., and Holcim, Inc., respectively, which together produced the remaining 26% of the clay commodity group. Common clay was largely used to make bricks, whereas high-alumina clay was used to make Portland cement.

Expanded Shale

Expanded shale in Utah is produced by Utelite, Inc., at their quarry and plant near Wanship in Summit County (figure 6). The company produced approximately 129,000 st in 2013, which was an increase of 8% from 2012 production. Expanded shale is a lightweight aggregate, which is sometimes called “bloated shale,” and is mainly used by the construction industry. It is produced by rapidly heating high-purity shale from the Cretaceous Frontier Formation to about 2000°F, which causes it to expand and vitrify. The resulting aggregate is durable, inert, uniform in size, and lightweight, with a density about one-half that of conventional aggregates. Their material is used in roof tile, concrete block, structural concrete, and horticulture additives, as well as for highway construction and

Table 4. Industrial mineral exploration projects in Utah, 2013.

Property	Deposit Type	County	Company	Progress
Blawn Wash	Potash; alunite alteration	Beaver	Potash Ridge Corporation	Completed preliminary feasibility study; proven and probable reserves of 26.4 million tons of potassium sulfate; 90 exploration holes completed
Bounty Potash	Potash; Great Salt Lake Desert, shallow brine	Box Elder	Mesa Exploration Company	BLM denied Pilot Valley prospecting permit application
Crescent Junction	Potash; Paradox Basin, deep evaporites	Grand	Pinnacle Potash International	Exploration drilling planned for 2014 on SITLA leases; previously completed one exploration hole
Green River	Potash; Paradox Basin, deep evaporites	Grand	American Potash LLC (Magna Resources Ltd.)	Received approval to explore on both BLM and SITLA land; exploration plan includes eight holes
Hatch Point	Potash; Paradox Basin, deep evaporites	San Juan	K2O Utah LLC (Potash Minerals Limited)	Received prospecting permits to explore on BLM land; completed JORC-compliant resource estimate; previously completed three exploration holes on SITLA land
Lisbon Valley	Potash; Paradox Basin, deep evaporites	San Juan	Potash Green Utah LLC (North American Potash Developments Inc.)	Pending prospect permit applications; holds SITLA leases; previously completed one exploration hole
Monument	Potash; Paradox Basin, deep evaporites	San Juan	Paradox Basin Resources Corp.	Pending prospect permit applications; holds SITLA leases
Paradox Basin	Potash; Paradox Basin, deep evaporites	Grand	Universal Potash Corporation	Pending prospect permit applications
Salt Wash, Whipsaw, White Cloud	Potash; Paradox Basin, deep brines and evaporites	Grand	Mesa Exploration Company	Pending prospect permit applications
Sevier Lake	Potash; Sevier (Dry) Lake, shallow brine	Millard	Peak Minerals Inc. (EPM Mining Ventures Inc.)	Completed preliminary feasibility study; in-place measured and indicated resource of 31.5 million tons of potassium sulfate; 431 exploration holes completed
Ashley Creek	Phosphatic shale (Meade Peak Member of the Phosphoria Fm.)	Uintah	Utah Phosphate Company (Agrium)	Holds SITLA leases in the Ashley Creek area west of Simplot's active phosphate mine; Drilled 51 exploration holes in 2013; had previously drilled 25 holes; additional property development planned for 2014
Diamond Mountain Phosphate	Phosphatic shale (Meade Peak Member of the Phosphoria Fm.)	Uintah	Utah Mineral Resources LLC	Holds SITLA leases and federal prospecting permit applications; planning exploration; site is east of Simplot's active phosphate mine
Dragon Mine	Halloysite specialty clay and iron oxide pigments	Juab	Applied Minerals Inc.	Expecting to commission a new 45,000 st per year processing plant in January 2014

loose fill. Some of Utelite's production is used locally along the Wasatch Front, but much of it is shipped out of state.

Gypsum

Four operators reported combined Utah gypsum production of about 279,000 st in 2013, which was 3% more than 2012 production. The 2013 production had an estimated value of \$3.27 million, which was also an increase compared to 2012. The high value was due to slight increases in both production and the price of crude gypsum (USGS, 2014a). The four Utah gypsum producers were Sunroc Corp., United States Gypsum Co., Diamond K Gypsum, Inc., and Nephi Gypsum (in descending production order). Two gypsum wallboard plants are located near Sigurd in Sevier County. The plant operated by United States Gypsum was active in 2013 (figure 6), but the plant operated by Georgia Pacific remains idle due to economic considerations. Utah gypsum (figure 8) is primarily used in raw or crude form by regional cement companies as an additive to retard the setting time of cement, and by the agriculture industry as a soil conditioner. Lesser amounts of the higher value calcined gypsum are used to make wallboard.

EXPLORATION AND DEVELOPMENT ACTIVITY

Industrial minerals exploration and development in Utah varies according to the commodity. The developments of high-value, internationally traded commodities, like potash, are relatively immune to fluctuating shipping costs and vary with international demand and the global economy. In contrast, the development of low-value commodities, like sand and gravel, are constrained by shipping costs and consequently, are sensitive to regional economic conditions.

Potash

Utah 2013 potash exploration focused on deep evaporites in the Paradox Basin, shallow brines in Sevier Lake and Great Salt Lake Desert, and alunitized $[KAl_3(SO_4)_2(OH)_6]$ volcanic rocks. The numerous Utah potash projects currently in exploration and development are listed and described in table 4.

Phosphate

Exploration for phosphatic shales in the Permian Meade Peak Member of the Phosphoria Formation is currently centered near the existing Simplot Phosphates, LLC, operation near Vernal along the south flank of the Uinta Mountains. West of Simplot, Agrium has completed extensive drilling to develop the Ashley Creek deposit (table 4). East of Simplot, Utah Mineral Resources, LLC, plans to drill the Diamond Mountain phosphate deposit, which was previously explored during the late 1960s.

Halloysite

The Dragon mine is situated in the southern Main Tintic mining district, of Juab County (figure 6). The Dragon mine has historical production of approximately 1.35 million st of halloysite, at least 500,000 st of iron ore, and uncertain, but smaller amounts of oxidized silver-gold ore. Halloysite $[Al_2Si_2O_5(OH)_4]$ is special kaolinite-group clay with a unique micro-tubular structure. The iron ore is an exceptionally pure goethite-hematite gossan, probably developed from a massive pyrite vein, and the halloysite is an unusual hydrothermal replacement of susceptible dolomite beds in the adjoining Upper Cambrian Opex Formation. The Dragon open pit has been closed since the last halloysite production in 1976.

Applied Minerals Inc. owns the Dragon pit and related property (38 patented lode claims). The company has a large mine permit, and is reopening the mine as an underground operation to produce halloysite and an iron-oxide pigment byproduct. Recent results from 80 shallow drill holes in the area indicate a measured resource of about 552,500 st of 64.8% halloysite (Applied Minerals Inc., 2011). Underground mine development is in progress and a new mill is under construction.

URANIUM

Historically, Utah is the third most productive uranium state, with the majority of its production from the Colorado Plateau. The spot price of U_3O_8 has been especially volatile over the last decade with spikes to \$136/lb in June 2007 and lows less than \$45/lb in 2009–2010. The spot price rebounded to \$73/lb in early 2011, but fell below \$50/lb after the March 2011 Fukushima nuclear power plant disaster in Japan. Uranium prices have remained low (generally less than \$45/lb) throughout 2012 and 2013. Uranium exploration and development in Utah has varied with these spot price fluctuations. Unlike the volatile spot price, long-term contract U_3O_8 prices have remained relatively constant, and declined only slightly to about \$60/lb. In the last few years of low spot prices, the uranium industry in Utah has consolidated, and Energy Fuels, Inc., acquired most of the promising uranium mines and prospects.

The continuing low uranium prices in 2013 (less than \$40/lb of U_3O_8) finally resulted in a halt to uranium mining operations in Utah. The Energy Fuels White Mesa mill (figure 6) continued operations using higher-grade uranium ore from breccia pipe deposits in Arizona, north of the Grand Canyon. The Utah mines were closed because Energy Fuels could purchase U_3O_8 on the spot market for less than the production cost at their Utah mines. This business strategy has the added corporate benefit of preserving their existing ore reserves. The significant known Utah uranium properties are listed in table 5. The White Mesa mill is expected to resume operations using an alternate feed waste material in 2015.

Table 5. Uranium projects in Utah, 2013.

Property	District	County	Company	Progress
San Rafael	San Rafael River	Emery	Energy Fuels, Inc.	Indicated resource: 758,050 tons at 0.23% U ₃ O ₈
Frank M	Henry Mountain	Garfield	SXR Uranium One, Inc.	Resource: 1.5 M tons at 0.12% U ₃ O ₈
North Wash	Henry Mountain	Garfield	Vane Minerals (US) LLC.	29 holes drilled, including 9.5 ft at 0.36% U ₃ O ₈
Tony M - Bullfrog	Henry Mountain	Garfield	Energy Fuels, Inc.	Permitted resource: 1.527 M tons at 0.24% U ₃ O ₈
Whirlwind	Beaver Mesa	Grand	Energy Fuels, Inc.	Permitted resource: 656,000 lb U ₃ O ₈
Thompson Project	Thompson	Grand	Energy Fuels, Inc.	Acquired 6672 acres
Rim - Columbus	Dry Valley	San Juan	Energy Fuels, Inc.	Permitted resource: 660,000 lb U ₃ O ₈
Marcy - Look	Elk Ridge	San Juan	Energy Fuels, Inc.	Acquired 907 acres
Blue Jay	Fry Canyon	San Juan	Energy Fuels, Inc.	Acquired 289 acres
Energy Queen (Hecla Shaft)	La Sal	San Juan	Energy Fuels, Inc.	Permitted resource: 1.2 M lb U ₃ O ₈
North La Sal	La Sal	San Juan	Vane Minerals (US) LLC.	Acquired 80 acres
Pandora - Snowball - Beaver	La Sal	San Juan	Energy Fuels, Inc.	On stand-by: 1.2 M lb U ₃ O ₈ reserve
La Sal #2	Lisbon Valley	San Juan	Laramide Resources Ltd.	Resource: 808,000 tons at 0.167% U ₃ O ₈
Lisbon mine area	Lisbon Valley	San Juan	Mesa Exploration Corp.	22 holes (~60,000 ft), including 3.5 ft at 0.28% U ₃ O ₈
North Alice Extension	Lisbon Valley	San Juan	Vane Minerals (US) LLC.	Resource: 43,000 tons at 0.14% U ₃ O ₈
Velvet	Lisbon Valley	San Juan	Energy Fuels, Inc. (Uranium One, Inc.)	Permitted resource: 580,000 lb U ₃ O ₈
Sage Plain (Calliham - Sage)	Ucolo	San Juan	Energy Fuels, Inc.	Resource: 642,971 tons at 0.22% U ₃ O ₈ and 1.39% V ₂ O ₅
Daneros (Lark Royal)	White Canyon	San Juan	Energy Fuels, Inc.	On stand-by: 740,000 lb U ₃ O ₈ inferred resource
Geitus	White Canyon	San Juan	Energy Fuels, Inc.	Resource: 40,000 ton at 0.3% U ₃ O ₈
Happy Jack	White Canyon	San Juan	Vane Minerals (US) LLC.	22 holes completed, including 1.5 ft at 0.39% U ₃ O ₈

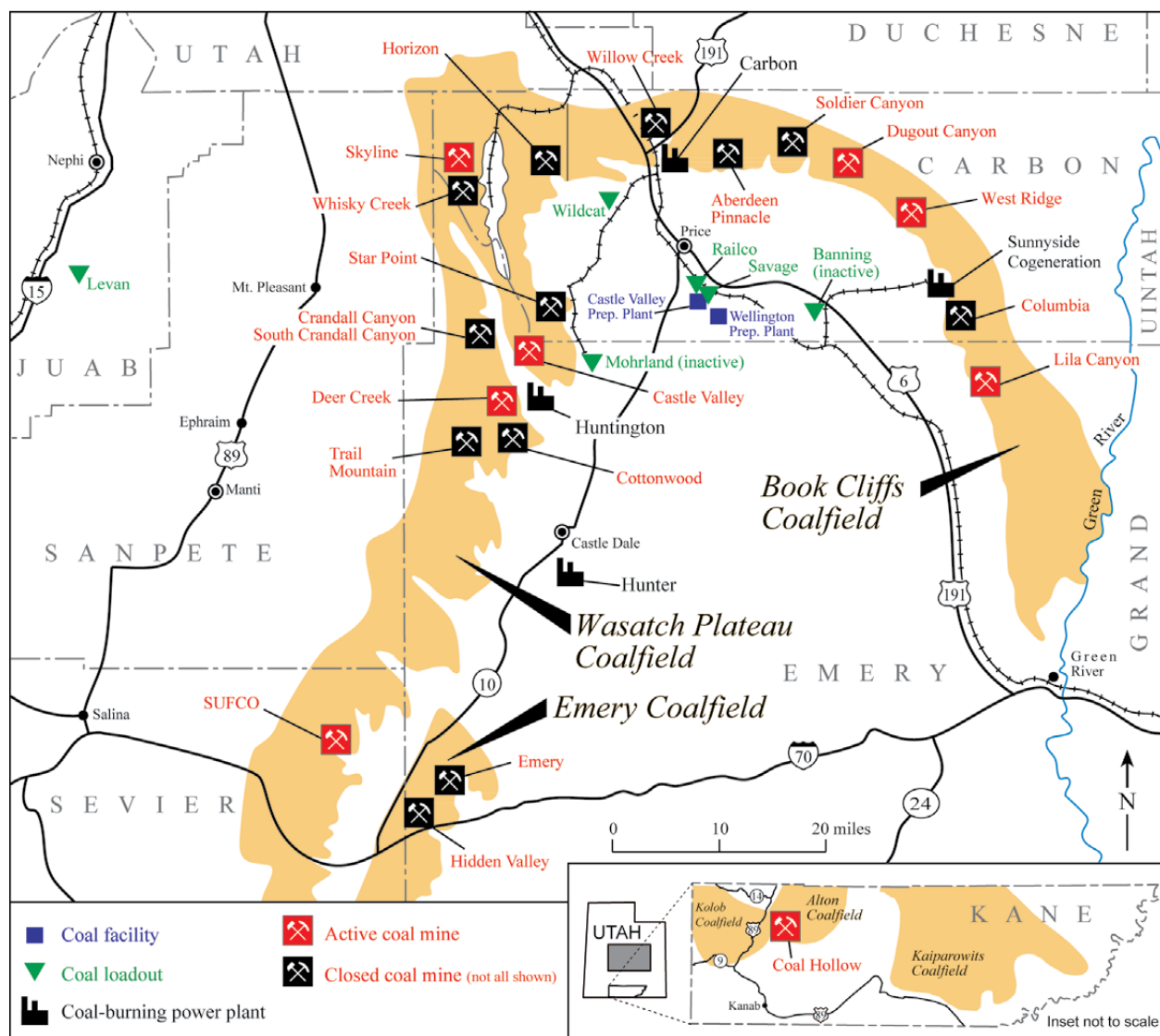


Figure 9. Location and status (at time of printing) of Utah coal mines and associated facilities.

COAL

Production and Values

Six Utah coal operators produced 17.0 million st of coal valued at \$579 million from eight underground mines in 2013 (figures 5 and 9). Overall production was only slightly lower than 2012 (-1.2%). Some mines, like Skyline, greatly increased production (+60%), but other mines, like Dugout, which shut down its longwall operations in 2012, greatly decreased production (-65%), keeping overall production relatively steady (table 2). The Horizon mine was idled in mid-2012 and eventually shut down in early 2013. The Emery mine has been idle/shut down since 2010; however, a small amount of coal was shipped from the Emery mine stockpile in 2013 and was counted as production. Even with the Intermountain Power Plant (IPP) fully recovered from a generator failure in 2012, which reduced its 2012 coal

demand by nearly 1.5 million st, demand for coal is still near historic lows. Consequently, production in 2014 is expected to decrease to 15.9 million st, with an estimated overall value of \$526 million. While the Canyon Fuel mines, which were purchased by Bowie Resources in summer 2013, are expected to increase production by 4%, the Deer Creek and West Ridge mines are expected to decrease production by 28% and 24%, respectively.

In 2013, the majority of Utah coal, 12.8 million st, was produced from the Wasatch Plateau coalfield, with 3.4 million st coming from mines in the Book Cliffs coalfield and 747,000 st from the Coal Hollow mine in the Alton coalfield. The majority of Utah coal, 83.0% (14.1 million st) was produced from federal land, while only 4.7% (801,000 st) was from state-owned land. The remainder of the 2013 production was from private land (7.9%, 1.3 million st, mostly from the Castle Valley and Coal Hollow mines) and county land (4.4%, 742,000

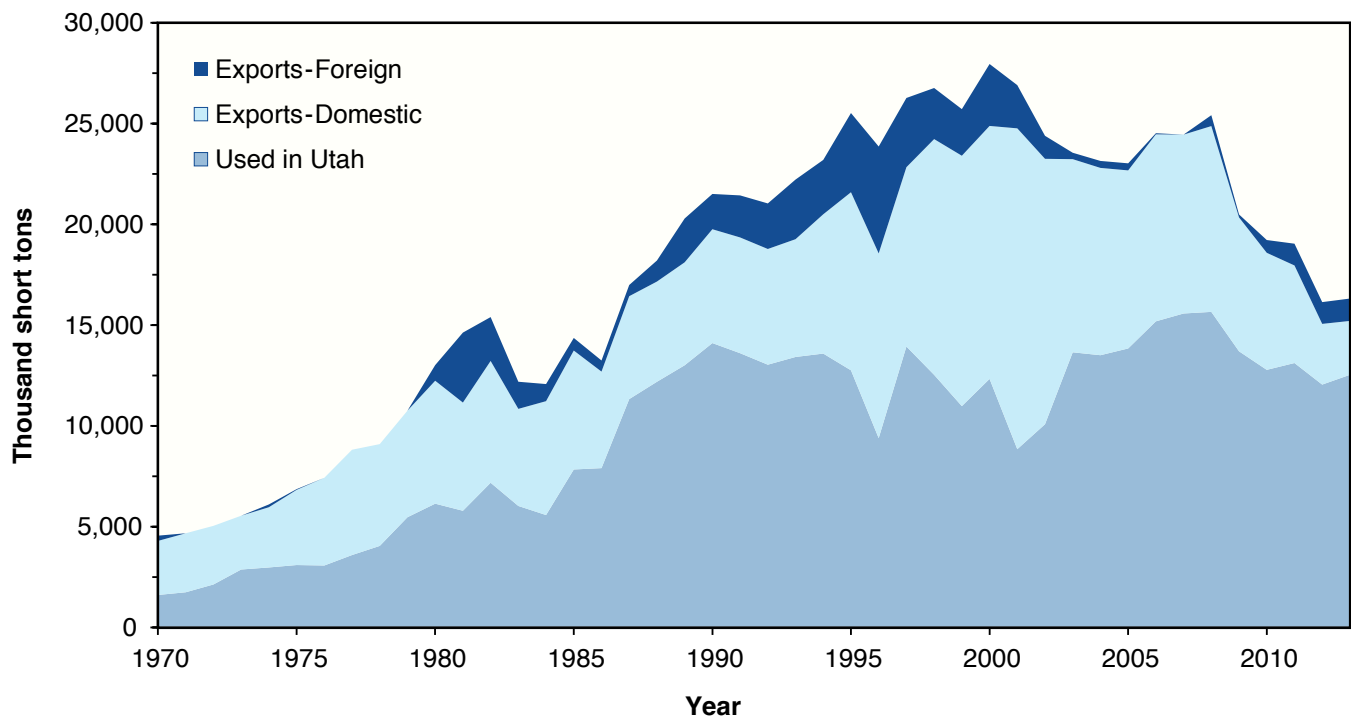


Figure 10. Distribution of Utah coal, 1970–2013.

st, from the Skyline mine in Carbon County).

Utah coal mines face steady reserve depletion and difficult mining conditions. In addition, the demand for Utah coal has sharply decreased over the past few years as power plants have switched from coal- to natural-gas-fired generation. In particular, several cogeneration plants in California, once a significant market for Utah coal, are converting to natural gas to comply with California's stricter environmental standards. The California market is also starting to influence Utah's in-state demand since the IPP is mostly owned by the city of Los Angeles. This owner has already stated that it will no longer purchase power from the IPP after its current power purchase agreement expires in 2027, unless the IPP converts to natural gas or implements carbon capture and storage technology. Thus, the average annual production total for Utah will likely be in the 15 to 16 million st range until 2027, after which there could be a significant reduction in demand.

The total amount of Utah coal distributed to market in 2013 totaled 16.3 million st, which is slightly less than the total coal produced for the year. As recently as 2001, 59% of Utah coal was exported to other states and only 33% was used in state (figure 10). In 2013, only 16% of Utah coal was shipped to other states, while 77% was used locally, signifying a large shift in Utah coal markets. The vast majority of Utah coal, 84%, still goes to the electric utility market, just now mostly in-state. As a result of the slowed U.S. economy, low natural gas prices, and new environmental regulations, demand for Utah coal to produce electricity decreased by 64% between

2008 and 2013. The economic recession and low natural gas prices also slowed demand for Utah coal in the industrial sector, where deliveries totaled 2.6 million st in 2013, which was significantly less than peak deliveries of 4.4 million st in 2003. Coal deliveries in 2014 are expected to remain in the 16 million st range, correlating with lower overall production. In contrast to the weak domestic market, Utah coal exports to other countries have increased, in particular the Asian coal market (figure 10). Demand for coal in Asia is particularly strong, but Utah operators will need increased access to port facilities to allow this market to offset slowing domestic demand.

For detailed statistics on Utah's coal industry (including information previously published in the annual Utah coal report), refer to extensive data tables located on the UGS's Utah Energy and Mineral Statistics website: <http://geology.utah.gov/emp/energydata>.

Exploration and Development Activity

UtahAmerican Energy, Inc. – Murray Energy Corp.

Lila Canyon mine: The Lila Canyon mine is located south of Horse Canyon in the Book Cliffs coalfield in Emery County. In spring of 2010, the company finished construction on 1200-ft-long rock slopes, began development work in the Sunnyside coal bed, and ultimately produced 72,000 st of coal in 2010. Development work continued during 2011, 2012, and 2013, with annual coal production reaching 157,000 st,

304,000 st, and 257,000 st, respectively. Coal production is expected to remain at the 250,000 st level until longwall mining commences in 2016. At full capacity, the mine could potentially employ up to 200 people and produce up to 4.5 million st of coal per year. Coal will be mined from federal leases where the merged upper and lower Sunnyside bed is about 13 ft thick. Up to 46 million st of recoverable coal is under lease and approximately 32 million st of additional reserves are available on 4200 acres of federal land to the south.

West Ridge Resources, Inc. – West Ridge mine: The West Ridge mine began operation in 1999 in the Book Cliffs coalfield with production from the lower Sunnyside bed. The West Ridge mine produced 2.63 million st of coal in 2013, which is up slightly from 2.58 million st produced in 2012, but significantly lower than the 3.6 million st produced in 2011. Production in 2014 is expected to decrease to about 2.0 million st. UtahAmerican estimates that the West Ridge mine has only about 3.4 million st of remaining recoverable coal under lease, and plans to shut down longwall operations in early 2016, when the longwall will be moved to Lila Canyon.

Canyon Fuel Company – Bowie Resource Partners, LLC

Bowie Resource Partners, LLC, bought the Canyon Fuel Company (the Dugout, Sufco, and Skyline mines) from Arch Coal in summer 2013. Bowie is based in Louisville, Kentucky, and owns the mines in a joint venture with Galena Private Equity Resources Fund, which is a unit of Amsterdam-based commodity trader Trafigura Beheer BV. Trafigura will sell coal produced by the mine.

Dugout Canyon mine: The Dugout Canyon mine, which is located in the Book Cliffs coalfield, shut down its longwall mining machine in late 2012, resulting in 2013 coal production of only 561,000 st from the Rock Canyon bed. This is significantly less than the 1.6 million st produced in 2012 and the 2.4 million st produced in 2011. Currently, Dugout is only mining with one continuous miner and expects to produce about 600,000 st in 2014. A second continuous miner could be brought online in 2014 if coal markets improve. Canyon Fuel estimates that the Dugout Canyon mine has about 12.8 million st of remaining recoverable coal under lease.

Skyline mine: Canyon Fuel Company's Skyline mine, which is located in the Wasatch Plateau coalfield, is currently mining in the Lower O'Connor "A" bed on their North (Winter Quarters) federal lease in Carbon County. Production from this bed increased significantly in 2013 to 3.1 million st and should remain at this level in 2014. Canyon Fuel estimates that about 15 million st of coal can be recovered from current leases. Future production at the Skyline mine could come from the unleased Flat Canyon tract, which is estimated to contain 25 to 30 million st of reserves.

Sufco mine: Sufco is Utah's largest coal producer and the 13th-largest producing underground coal mine in the United States (2012 data). It is also the only active coal mine in Sevier County. Sufco produced 6.0 million st of coal in 2013 from the upper Hiawatha bed, which is 5.5% more than in 2012, but 25% less than record high production of 7.9 million st achieved during 2006. Production at Sufco is expected to increase slightly to 6.3 million st in 2014. Canyon Fuel estimates that 32 million st of reserves remain under lease in the upper and lower Hiawatha beds. Of note, the new Quitcupah Creek paved road opened in late 2013, which significantly reduces transit times for trucks from the mine that transport coal to Emery County power plants.

Greens Hollow tract: Canyon Fuel has nominated the federal Greens Hollow coal tract for leasing, which is located northwest of the already acquired Quitcupah lease. A draft Environmental Impact Study (EIS) was issued in the spring of 2009 and the record of decision, favoring the lease of the tract, was made in December 2011. The record of decisions was subsequently retracted until further study could be completed, with a new decision expected in spring 2014. The Greens Hollow tract is estimated to contain about 73 million st of reserves within the lower Hiawatha bed.

CONSOL Energy

Emery mine: The CONSOL Energy Emery mine is the company's only mine in the western United States. From 2005 through 2010, the mine produced about one million st annually from the Ferron Sandstone I bed. However, CONSOL indefinitely idled the mine in December 2010, citing lack of coal demand. The mine is currently for sale.

Rhino Resource Partners, LP

Castle Valley mines: Rhino purchased the Bear Canyon mines from C.W. Mining (Co-Op) in 2010 and changed their name to Castle Valley. Full-scale operation with two continuous miners produced 875,000 st in 2013, and the mine's production is expected to be about the same in 2014. Rhino estimates that about 7 million st of reserves remain on leased land, but about 51 million st of recoverable reserves could be available in the Tank, Blind Canyon, and Hiawatha beds in the surrounding area.

Energy West Mining Company – PacifiCorp

Deer Creek mine: Production at the Deer Creek mine decreased to 2.8 million st in 2013 and is expected to decrease again in 2014 to 2.0 million st. This decrease in production is mostly the result of union labor issues related to the negotiation of a new labor contract. Longwall development work via continuous miner ceased in late 2013, but longwall operations will continue until the currently developed panels are exhausted. Continuous miner operations should resume if

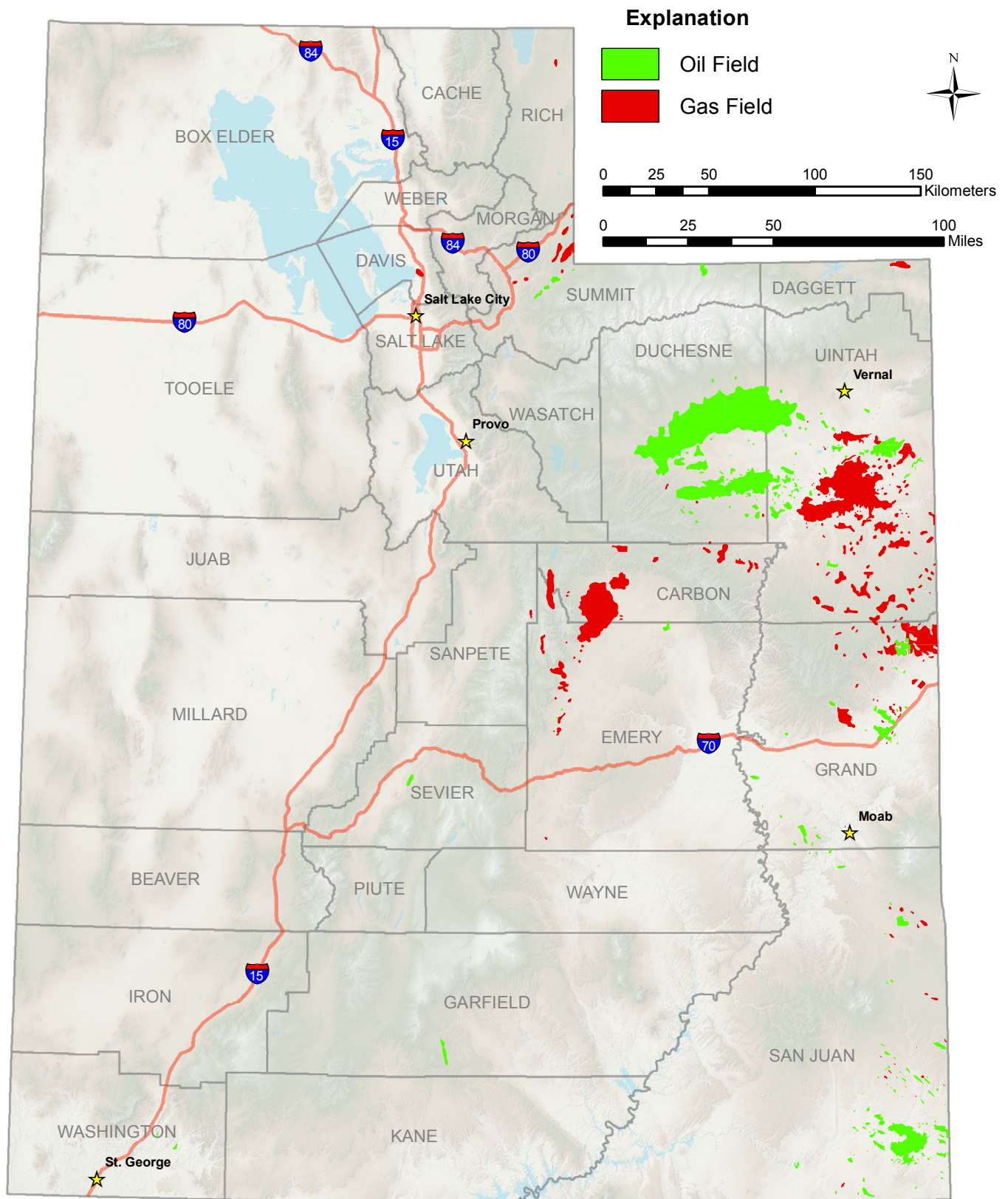


Figure 11. Location of oil and gas fields in Utah.



Figure 12. Natural gas drill rig on the Natural Buttes field, Uintah County, Utah.

a new labor contract is approved. There are about 9 million st of coal remaining under lease in the Hiawatha bed in the Mill Fork tract.

Fossil Rock Fuels – PacifiCorp

Cottonwood tract: On December 31, 2007, SITLA held a sale of the Cottonwood Competitive Coal Leasing Unit. The tract was awarded to Ark Land Co., which is a subsidiary of Arch Coal, Inc., also the former owner of Canyon Fuel Co. Two coal leases were issued, one for 8204 acres covering lands within the 1998 land exchange Cottonwood Coal Tract and the other for 600 acres within an adjacent SITLA section. In mid-2011, the Cottonwood lease was transferred from Ark Land to Fossil Rock Fuels, which is a subsidiary of PacifiCorp and Rocky Mountain Power, as part of a settlement of litigation between Arch Coal and PacifiCorp. The Cottonwood tract is adjacent to PacifiCorp's existing, but inactive, Train Mountain federal lease. Total recoverable coal in the Hiawatha bed for the combined Cottonwood leases is estimated at 49 million st. Fossil Rock Fuels has recently started an exploration pro-

gram on the newly acquired Cottonwood lease.

America West Resources, Inc.

Hidden Splendor Resources, Inc. – Horizon mine: The Horizon mine is located approximately 11 miles west of Helper in the Wasatch Plateau coalfield and was idled in July 2012 after producing 210,000 st of coal for the year. The mine was idled after MSHA required extensive changes to the mine plan and a portion of the mine was sealed. In February 2013, the company filed for bankruptcy with a subsequent bankruptcy sale in April. The mine failed to sell as a whole and only some of the equipment was sold. Before the mine closed, America West estimated that 16 million st of coal resources remained on leased land.

Alton Coal Development

Coal Hollow mine: In 2011, Alton Coal Development began production from the new Coal Hollow mine in the Alton coalfield in Kane County, southern Utah. Surface-mining production on the company's private property totaled 403,000 st for

2011 and increased to 747,000 st in 2013. Production in 2014 is expected to remain at the 750,000 st level. In the spring of 2014, the mine plan was revised and highwall mining will begin with access from the mine's current open pits. This new mine plan will substantially reduce surface disturbances by the mine. Full production at the Coal Hollow mine could total 2.0 million st per year, but reaching that amount depends on the acquisition of surrounding federal lands. The BLM is currently preparing a draft EIS for the proposed federal leasing action. Alton's private lease, as well as two recently leased state sections, are estimated to contain about 12.0 million st of recoverable coal, while reserves on the surrounding federal mining areas are estimated between 35 and 40 million st. The Coal Hollow mine produces subbituminous Dakota Formation coal from the Smirl bed, which averages about 10,000 btu/lb, about 1% sulfur, and 8% ash.

CRUDE OIL AND NATURAL GAS

Production and Values

Most of the statistical data presented here on oil and gas were from the DOGM web site (at: <http://oilgas.ogm.utah.gov/index.htm>). At an estimated 2013 value of \$5.07 billion, oil and gas accounted for 90% of the total value of fuel commodities produced in Utah. During 2013, 34.9 million bbls of oil and 470.5 billion ft³ of gas were produced from Utah oil and gas fields (figure 11). Oil and gas values increased about \$821 million (19%) in 2013 as oil production and prices increased and declining gas production was offset by higher gas prices. Utah oil prices rose 57% between 2005 and 2013, while production more than doubled. During the same period gas prices declined by 50%, while dry gas production rose by 53%. Thus, gas and oil are following different market trends with oil production following price upward, but gas production increasing despite falling prices. In 2014, gas prices are expected to rise slightly. Utah 2013 oil and gas production came from 11,710 producing wells (4702 oil wells and 7008 gas wells), which was an increase from the 11,091 producing wells in 2012 (4228 oil wells and 6863 gas wells).

Oil made the largest contribution to the value of Utah fuel production in 2013, with a value of \$2.96 billion, which was about \$463 million (19%) more than in 2012. About 96% of the oil produced in Utah during 2013 came from Duchesne, Uintah, San Juan, and Sevier Counties (in decreasing production order). The five largest producing oil fields in 2013, Monument Butte (Duchesne and Uintah), Altamont (Duchesne), Greater Aneth (San Juan), Bluebell (Duchesne and Uintah), and North Myton Bench (Duchesne), accounted for about 54% of Utah oil production.

Natural gas made the second largest contribution to the value of fuel commodities produced in Utah during 2013, with an estimated value of \$2.11 billion (including natural gas liq-

uids), which is \$358 million (21%) more than in 2012. About 96% of the gas produced in Utah during 2013 came from Uintah, Carbon, Duchesne, and Emery Counties (in decreasing production order). The five largest producing gas fields in 2013 were Natural Buttes (Uintah), Drunkards Wash (Carbon), Peters Point (Carbon), Nine Mile Canyon (Carbon), and Red Wash (Uintah). Together they accounted for 74% of the 2013 gas production. Notably, production from the Natural Buttes alone accounted for more than half (58%) of the gas produced in Utah during 2013.

Exploration and Development Activity

Oil and gas exploration and development activity in Utah declined during 2013. Compared to 2012, the number of wells permitted fell 23% (from 2105 to 1611), and the number of wells started (spuds) decreased 10% (from 1107 to 991). The most active counties were Duchesne with 794 new well permits and 443 well spuds, Uintah (figure 12) with 737 new well permits and 521 well spuds, and San Juan with 50 new well permits and 15 new well spuds. These three counties accounted for 98% of the new well permits and well spuds in Utah during 2013. The 974 new oil and gas wells completed during 2013 were less than the 1077 completed in 2012. The new oil and gas wells completed in 2013 consist of 729 new wells within established field boundaries, 133 wells drilled adjacent to existing fields, and 112 wildcat wells drilled in unproven areas. The 974 new wells completed in 2013 include 11 dry holes that were plugged and abandoned, 664 oil wells, 291 gas wells, and 8 service wells (injection or disposal wells). The ratio of new oil wells to new gas wells drilled has increased in recent years in response to high oil prices and depressed gas prices; this trend is expected to continue until gas prices increase.

UNCONVENTIONAL FUELS – OIL SHALE AND OIL SAND

Exploration and Development Activity

Oil Shale

The upper Green River Formation in the Uinta Basin of Utah contains one of the largest deposits of oil shale in the world. The oil shale deposit contains an estimated in-place resource of 1.3 trillion bbls (USGS Oil Shale Assessment Team, 2011) and a potentially economic resource of 77 billion bbls (Vanden Berg, 2008). The richest Green River oil shale horizon is the Mahogany zone, where individual beds can yield 80 gallons of oil per ton of rock. The Mahogany zone is 70 to 120 feet thick and is accessible via extensive outcrops along the eastern and southern flanks of the basin.

Company development activities: The outcrop accessibility, low dip, and shallow cover of Utah oil shale deposits make

surface/underground mining and surface retort the preferred technology to recover oil from the shale. Currently, three companies are pursuing oil shale development in Utah: Enefit American Oil, Red Leaf Resources, and TomCo Energy.

Enefit American Oil is an Estonian company that acquired 100% of OSEC (Oil Shale Exploration Company), including their private land (the Skyline property), state leases, and a U.S. BLM Research, Development, and Demonstration oil shale lease. Enefit's plan is to develop a 50,000 bbls/day oil shale operation, consisting of a surface/underground mine (which would process nearly 30 million st of shale per year), up to six surface retorts and circulating fluidized bed combustion units, and a shale oil upgrader. The project will commence in two 25,000 bbl/day stages; timing will depend on the acquisition of necessary permits. Recent work has focused on drilling several wells and recovering core to prove up the resource and collect fresh mining-horizon samples for testing the company's retort technology. In addition, several water-monitoring wells have recently been drilled. Although the project will begin on private land, a utility corridor that crosses BLM land is planned to support the development. An Environmental Impact Statement for the corridor is expected to be completed in late 2015.

Red Leaf Resources is a Utah company with several state oil shale leases on the southeastern side of the Uinta Basin. Red Leaf has developed a modified in situ retort process called Ecoshale technology. The process involves surface mining a pit, lining the pit with an impermeable clay layer, placing the oil shale back in the pit with a series of pipes, and covering the filled pit (capsule) with clay and topsoil. Shale in the capsule is retorted by hot air circulating through the pipes. Reclamation can commence while the capsule is still retorting the shale. This process has been tested on a pilot scale level and the company recently acquired a large mining permit to construct a much larger test capsule. Commercial plans are to produce 9500 bbls/day of oil from several capsules running simultaneously. In March 2012, Red Leaf announced the closing of a joint venture with Total E&P USA Oil Shale (a U.S. affiliate of Total USA). Total will fund an 80% share of the early production system expenses, which are estimated at approximately \$200 million.

TomCo Energy is a United Kingdom based company with SITLA leases in the Uinta Basin. The company plans to use the Red Leaf Ecoshale technology on their "Holiday block" property. The company has drilled nine exploratory wells to define their resource and has begun work to acquire the necessary development permits.

Oil Sand

North America has the greatest oil sand resources in the world, most of which are in Canada. Utah oil sands, though small compared to Canadian resources, are the largest resource in

the United States. Utah oil sand deposits contain 14 to 15 billion bbls of in-place oil, with an additional estimated resource of 23 to 28 billion bbls. Twenty-four individual deposits exist in the Uinta Basin, mainly around its periphery, and an additional 50 deposits are scattered throughout the southeastern part of the state. Utah's major oil sand deposits individually have areal extents ranging from 20 to over 250 square miles, as many as 13 pay zones, gross thickness ranging from 10 to more than 1000 feet, and overburden thickness ranging from zero to over 500 feet.

With the current high price of crude oil as an incentive, new drilling, bitumen extraction, and upgrading techniques developed in Canada may provide the necessary knowledge for successful and sustainable development of oil sand in Utah in the near future. However, factors such as site accessibility, adequate infrastructure, water availability, environmental concerns, permitting, and the problems associated with the heterogeneity of reservoir sands must be resolved before economically viable oil sand development can become a reality in Utah.

Company development activities: U.S. Oil Sands is the most active company seeking to develop Utah's oil sand resources. The company has several SITLA leases within the PR Springs oil sand deposit in the southern Uinta Basin. The company plans to surface mine the oil sand and extract the bitumen using a solvent-based technology. In the summer of 2011, the company drilled more than 180 wells on their leases to define the resource. The company recently acquired all necessary permits and capital to open its mine. Operations are expected to begin in spring/summer 2014.

One of Utah's most promising oil sand deposits is located along Asphalt Ridge near Vernal, Utah. Several companies have tried to develop oil sand operations in the area, but in 2013 no commercial activity took place here besides limited extraction for use as road pavement. The Sunnyside oil sand deposit, east of Price, Utah, has also recently received attention from companies, including one that has proposed to access the deposit via underground mining.

NEW MINERALS INFORMATION

The following recent publications provide new information on the energy and mineral resources of Utah. Rupke and Boden (2013a) described the gypsum resources of the San Rafael Swell, Utah. Rupke and Boden (2013b) reported on frac sand potential on selected SITLA lands. Boden and others (2013) compiled production and values and exploration and development activity for Utah's extractive resource industries for 2012. These and other publications are available through the Utah Department of Natural Resources Map and Bookstore (<http://mapstore.utah.gov>). Additional geographic information system (GIS) data on Utah is available for free

download at <http://agrc.its.state.ut.us/> and <http://geology.utah.gov/databases/index.htm>. The UGS also maintains a comprehensive repository for Utah energy and mineral data at <http://geology.utah.gov/emp/energydata/index.htm>. The website contains over 130 tables and 50 figures (in both Excel and PDF formats) in nine chapters that are continuously updated as new data become available. Canadian National Instrument Technical Reports for mineral properties in Utah are available on the UGS website at <http://geology.utah.gov/utahgeo/rock-mineral/index.htm#minactivity>.

RECLAMATION AND THE ENVIRONMENT

The U.S. Department of Energy (DOE) and the State of Utah agreed to move the 11.9 million st of old Atlas uranium mill tailings located along the Colorado River near Moab. The tailings will be moved 30 mi north to a site near Crescent Junction. The DOE transports the tailings by rail to a 250-acre disposal cell excavated in the impermeable Cretaceous Mancos Shale. The project began shipping tailings in April 2009, moved 723,808 st in 2013, and moved a total of 6,457,537 st by the end of 2013 (Kym Bevan, DOE, written communication, April 2013).

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