

# UTAH'S EXTRACTIVE RESOURCE INDUSTRIES 2012

*by Taylor Boden, Michael Vanden Berg, Ken Krahulec, and David Tabet*



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**2013**

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*Cover photo: Potash and salt evaporation pond at Intrepid Potash-Wendover in Tooele County, Utah. Photo by Mark Gwynn.*

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contact

Natural Resources Map & Bookstore

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**UTAH GEOLOGICAL SURVEY**

contact

1594 W. North Temple, Suite 3110

Salt Lake City, UT 84116

telephone: 801-537-3300

website: [geology.utah.gov](http://geology.utah.gov)

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# CONTENTS

ABSTRACT.....	1
INTRODUCTION .....	1
Background.....	1
Historical Context .....	1
Industry Overview.....	2
National Rankings.....	4
Outlook for 2013 .....	5
BASE AND PRECIOUS METALS .....	6
Production and Values .....	6
Copper .....	7
Magnesium.....	7
Molybdenum.....	7
Iron Ore.....	9
Beryllium .....	9
Vanadium.....	9
Gold.....	9
Silver .....	9
Exploration and Development Activity.....	10
Bingham Canyon.....	10
Lisbon Valley Copper .....	10
Iron Springs .....	10
Drum Mountains .....	11
Rocky and Beaver Lake Districts.....	11
Tecoma District.....	11
Goldstrike District.....	11
Confusion Range.....	11
Gold Springs District .....	11
Gold Hill District.....	13
Tintic District.....	13
Star District .....	13
Spor Mountain .....	13
Miscellaneous Base Metal and Precious Metal Developments .....	14
INDUSTRIAL MINERALS .....	14
Production and Values .....	14
Potash, Salt, and Magnesium Chloride .....	14
Sand and Gravel, Crushed Stone, and Dimension Stone .....	15
Portland Cement, Lime, and Limestone.....	15
Phosphate .....	15
Sulfuric Acid .....	16
Gilsonite.....	16
Bentonite, Common Clay, and High-Alumina Clay .....	16
Expanded Shale.....	17
Gypsum .....	17
Exploration and Development Activity.....	17
Potash.....	17
Halloysite.....	17
Gilsonite.....	17
URANIUM.....	17
Production and Value .....	17
Exploration and Development Activity.....	18
Energy Fuels, Incorporated .....	19
Uranium One, Incorporated .....	20
Laramide Resources Limited.....	20
COAL.....	20
Production and Values .....	20
Exploration and Development Activity.....	22
UtahAmerican Energy, Incorporated – Murray Energy Corporation.....	22
Lila Canyon mine .....	22
West Ridge Resources, Incorporated – West Ridge mine.....	22



Canyon Fuel Company – Arch Coal.....	22
Dugout Canyon mine.....	22
Skyline mine .....	23
SUFCO mine.....	23
Greens Hollow tract.....	23
CONSOL Energy.....	23
Emery mine.....	23
Rhino Energy.....	23
Castle Valley mines.....	23
Energy West Mining Company – PacifiCorp .....	23
Deer Creek mine .....	23
Fossil Rock Fuels – PacifiCorp.....	23
Cottonwood tract .....	23
America West Resources, Incorporated.....	24
Hidden Splendor Resources, Incorporated – Horizon mine .....	24
Alton Coal Development.....	24
Coal Hollow mine.....	24
CRUDE OIL AND NATURAL GAS.....	24
Production and Values .....	24
Exploration and Development Activity.....	24
UNCONVENTIONAL FUELS – OIL SHALE AND OIL SAND .....	26
Exploration and Development Activity.....	26
Oil Shale.....	26
Operators.....	27
Oil Sand.....	27
Operators.....	27
NEW MINERALS INFORMATION.....	27
RECLAMATION AND THE ENVIRONMENT.....	28
ACKNOWLEDGMENTS.....	28
REFERENCES.....	28

## FIGURES

Figure 1. Total annual value of Utah's energy and mineral production, inflation adjusted to 2012 dollars, 1960–2012.....	3
Figure 2. Value of Utah's annual fuel production in nominal dollars, by industry sector, 2003–2012 .....	4
Figure 3. Value of Utah's annual nonfuel production in nominal dollars, by industry sector, 2003–2012.....	4
Figure 4. Total annual value of Utah's nonfuel mineral production in nominal dollars, 2003–2012 .....	5
Figure 5. Utah's annual coal production and value in nominal dollars, 2000–2013 .....	6
Figure 6. Base and precious metals, selected industrial minerals, and uranium production locations in Utah during 2012.....	8
Figure 7. Base and precious metals, and uranium exploration and development activity locations in Utah during 2012.....	12
Figure 8. Rig working on one of Kennecott Exploration Company's deep porphyry copper exploration holes on Big Hill in the East Tintic mining district, Utah County .....	13
Figure 9. Simplot Phosphates operation north of Vernal in Uintah County, Utah .....	16
Figure 10. Location and status (at time of printing) of Utah's coal mines and associated facilities.....	21
Figure 11. Location of oil and gas fields in Utah .....	25
Figure 12. Mahogany zone oil shale beds in the upper Green River Formation.....	26

## TABLES

Table 1. Utah estimated energy and mineral production values in nominal dollars, by energy and mineral industry segment, 2003–2012.....	5
Table 2. Coal production and recoverable reserves in Utah by coal mine, 2011–2013 .....	7
Table 3. Potash exploration projects in Utah, 2012 .....	18
Table 4. Uranium projects in Utah, 2012. ....	19

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## ABSTRACT

Utah energy and mineral companies produced an estimated gross value of \$8.2 billion in energy and mineral commodities in 2012. On an inflation-adjusted basis, this is a \$1.2 billion (12%) decrease from 2011, and a \$1.9 billion (18%) decrease from the 2008 record high of \$10 billion. Total energy production in 2012 was valued at \$4.5 billion, including \$2.5 billion from crude oil production, \$1.3 billion from natural gas production, \$0.6 billion from coal production, and \$0.03 billion from uranium production. Nonfuel mineral production was valued at \$3.7 billion, including \$2.1 billion from base metal production, \$1.2 billion from industrial mineral production, and \$0.4 billion from precious metal production.

U.S. Geological Survey preliminary data ranked Utah as 7th nationally in 2012 for the value of nonfuel mineral production, accounting for approximately 4.6% of the United States total. In 2012, copper was the largest contributor to the value of nonfuel minerals in Utah, having an estimated value over \$1.38 billion 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 2012 were the brine-derived products potash, salt, and magnesium chloride, having a combined estimated value of \$421 million. Utah remains the only state in the nation to produce magnesium metal, beryllium concentrate, and gilsonite.

From 2011 to 2012, Utah experienced an increase in oil and gas exploration and development activity, with the number of wells permitted increasing from 1516 to 2103, and the number of wells started (spudded) increasing from 988 to 1099. Utah's coal production decreased 14.5% in 2012, with a further decrease expected in 2013 due to a weak domestic coal market. Energy Fuels Resources was responsible for all uranium produced in Utah during 2012, having acquired Denison Mines Corporation during the year; however, all uranium mining in Utah was stopped near the end of 2012 due to low uranium prices. In 2012, mineral exploration and development declined slightly relative to 2011, and exploration primarily focused on potash, copper, and gold. The number of new unpatented mining claims filed in Utah was 3060 in 2012, and at the end of the year the Bureau of Land Management had a total of 20,862 active unpatented mining claims. The number of new claims and total claims in 2012 are both down from 2011.

## 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 figures for 2011 production and value were made available in the fourth quarter of 2012; subsequently, we revised for this report, after comparing 2011 and 2012 production and value, some of the production and value figures published in *Utah's Extractive Resource Industries 2011* (Boden and others, 2012). The 1996–2012 Utah mineral/mining summaries are available on the UGS website at <http://geology.utah.gov/utahgeo/rockmineral/index.htm#minactivity>.

Since 1993, Utah's mineral industry activity summaries have categorized mineral production and value into four broad segments consisting of base metals, precious metals, industrial minerals, and energy minerals (coal and uranium). The *Utah Mining 2010* publication (Gwynn and others, 2011) marked the first time that the annual Utah coal report was combined with the mineral activities summary. The *Utah's Extractive Resource Industries 2011* publication (Boden and others, 2012) marked the first inclusion of crude oil, natural gas, and unconventional fuels production, value, exploration, and development activity summaries, resulting in one comprehensive energy and mining activity report for Utah. The U.S. Geological Survey (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 from individual operator surveys, company websites, trade industry publications, and personal correspondence.

### Historical Context

Utah contains a remarkable range of geologic energy and mineral wealth. The development of these resources for over 160 years has been, and will continue to be, an important benefit to Utah and the entire 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, and their earliest efforts included recovering salt from Great Salt Lake; coal mining near Coalville, Wales, and Cedar City; quarrying building stone; and manufacturing 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, and 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 economic, exceeding a value of \$100 million by 1917 (Stowe, 1975). Development of mining and transportation infrastructure in Utah established it as 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 the copper, gold, silver, and molybdenum produced from the deposit currently make it one of the most valuable operations in the U.S. Utah is the nation's only source of gilsonite (since the late 1880s; Boden and Tripp, 2012), beryllium concentrate (since 1969; Alexander, 2006), and magnesium metal (since 1972; Krahulec, 2006). Demand for uranium used in nuclear weapons and power resulted in the development of Utah's uranium deposits in southeastern Utah starting in the 1950s and 1960s. In 1952, Charlie Steen made the biggest discovery of uranium ore to date 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 deposit locally used in Utah was accidentally discovered in 1891, from the drilling of a water well in Farmington Bay on the eastern shore of Great Salt Lake (UGS, 2006). The gas was later transported from several wells near this area by a wooden pipeline to Salt Lake City. Oil was first discovered in Utah in the early 1900s at three places: Rozel Point on the shore of Great Salt Lake in Box Elder County, Mexican Hat in San Juan County, and near the town of Virgin in Washington County (UGS, 2006). By 1960, Utah was the 10th largest oil-producing state in the nation.

In 1969, the total value of minerals produced in Utah and sold commercially 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 energy and minerals produced annually in Utah, including metals, nonmetals, mineral fuels, and hydrocarbon fuels, reached a record high in 2008. Worldwide recession beginning in late 2008 affected nearly every aspect of Utah's economy, including mining, and is reflected in the decreased value

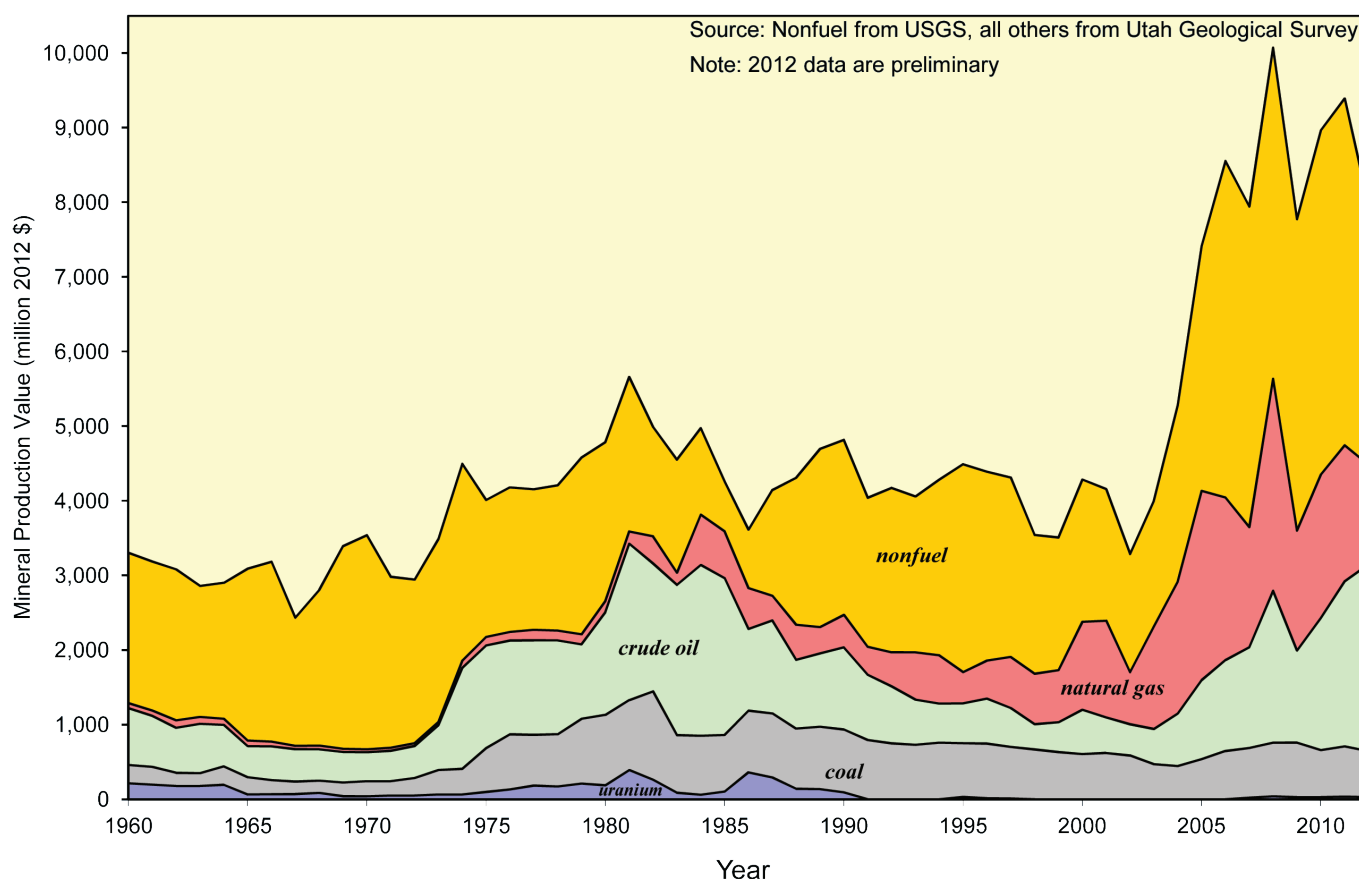
of Utah's energy and mineral production in 2009. Ongoing economic recovery in 2012 has resulted in a relatively high value for Utah's energy and mineral production.

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 about 6.0% in the 1960s to about 1.5% in the early 2000s as the state grew in other economic sectors. However, the contribution of the energy and mineral industries to Utah's GDP has grown in recent years to as high as 2.5% in 2008, and was approximately 1.9% in 2012 (U.S. Bureau of Economic Analysis, 2013). The demand and price for energy and mineral commodities produced in Utah will likely continue to rise in the future, ensuring that energy and mineral industries will remain an important contributor to the state's economy.

## Industry Overview

Compared with our estimates, the USGS estimates the gross value of all energy and mineral commodities produced in Utah during 2012 at \$8 billion (nonfuel value from USGS, 2013a), representing a 15% decrease from the 2011 inflation-adjusted value of \$9.4 billion (figure 1). The decrease in values of base metals, precious metals, natural gas, and coal from 2011 to 2012 was made up to some degree by a significant increase in the value of oil. The 2012 total energy and mineral production value is the fifth highest behind the inflation-adjusted record of \$10 billion achieved in 2008. Prices for a number of energy and mineral commodities continued to remain relatively high from 2011 to 2012. However, lower copper and molybdenum production and price resulted in a significantly lower value for base metals than in 2011. Despite relatively high prices, a large decrease in precious metals production in 2012 resulted in a major decrease in value, and together with copper's large share of metals value, the overall value of metals decreased significantly from 2011. Industrial minerals value in 2012 remained approximately equal to the record set in 2011. Two important factors for industrial minerals retaining their value were major construction projects and the continued high value and production of brine-derived potash products in Utah. The value of coal produced in Utah decreased in 2012 as coal production hit a 20-year low. Demand for coal by electric utilities continues to suffer from the recession-related drop in demand for electricity. In addition, several out-of-state power plants have converted to natural gas. The combined value of oil and gas production from Utah decreased slightly from 2011 to 2012, with a significant increase in the value of oil, but a decrease in the value of natural gas. The increase in the value of oil production is due mainly to increased production in 2012; however, even though natural gas production increased in 2012, much lower prices resulted in a lower value than in 2011. Despite lower uranium prices, Utah uranium production value increased due to higher produc-





**Figure 1.** Total annual value of Utah's energy and mineral production, inflation adjusted to 2012 dollars, 1960–2012.

tion in 2012. Utah's uranium production was consolidated by Energy Fuels Resources' acquisition of Denison Mines Corporation in 2012, but lower uranium prices resulted in shut-down of all mines near the end of 2012.

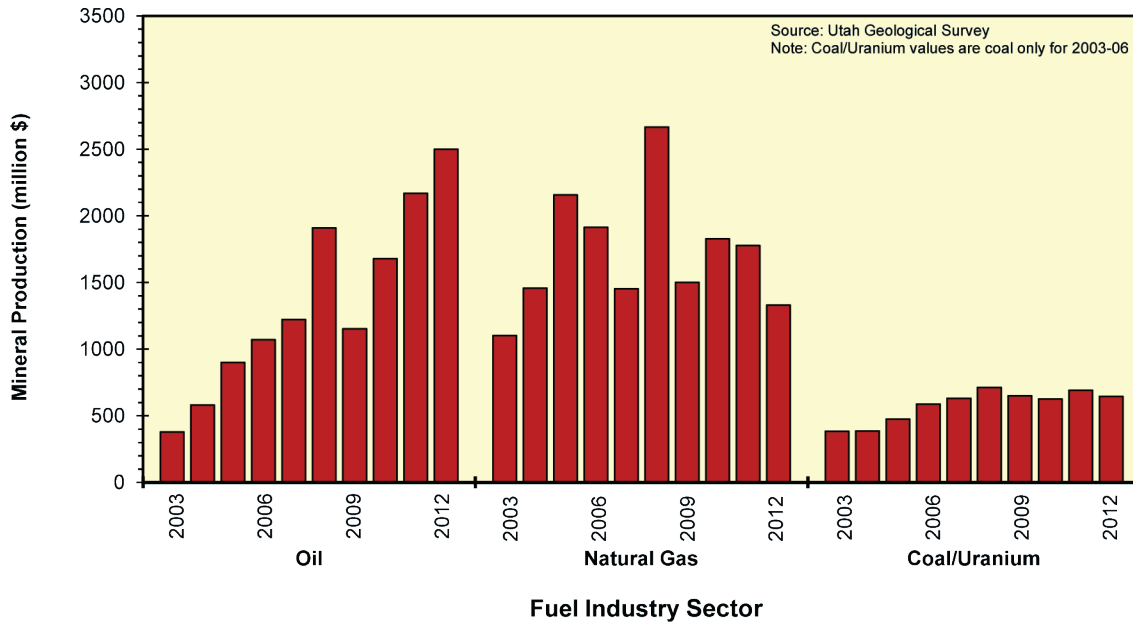
The total value of Utah's fuel production in 2012 is estimated to be \$4.5 billion, and the total value of the nonfuel minerals production is estimated to be \$3.7 billion (figures 2 and 3; table 1). The commodity segment individual contributions were approximately as follows: oil, \$2.50 billion (30% of total); base metals, \$2.12 billion (26% of total); gas, \$1.33 billion (16% of total); industrial minerals, \$1.21 billion (15% of total); coal, \$613.8 million (7% of total); precious metals, \$405.9 million (5% of total); and uranium, \$30.9 million (0.4% of total) (figures 2 and 3; table 1). Compared to 2011, the 2012 values of base metals decreased \$500 million (19%), oil increased \$331 million (15%), gas decreased \$447 million (25%), industrial minerals remained approximately equal, precious metals decreased \$306 million (43%), coal decreased \$46 million (7%), and uranium increased \$1.4 million (5%).

Mineral exploration and development declined slightly in 2012 relative to 2011 and the primary exploration focus remained on potash, copper, and gold. Commodity price

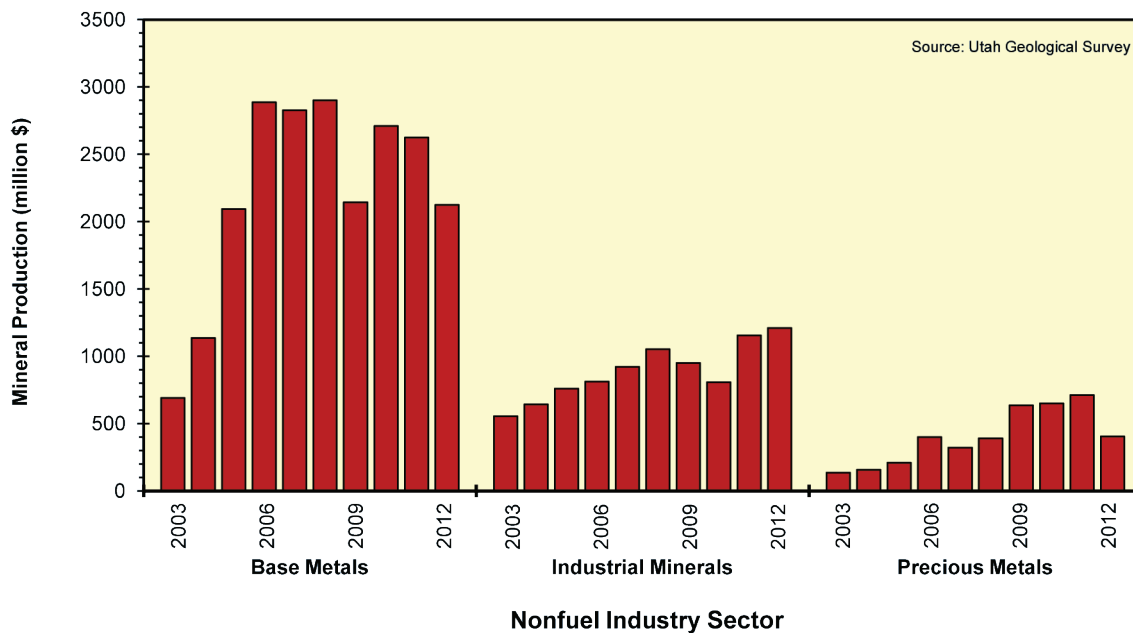
indices generally peaked in July 2008, collapsed later that year, then gradually rebounded to reach new highs in 2011, but were off those highs in 2012.

The number of new unpatented mining claims filed in Utah in 2012 was 3060. Juab (copper, gold, silver), Beaver (copper), Box Elder (gold, silver), Tooele (copper, gold), and Grand (uranium) counties were the most active with each recording over 200 new mining claims in 2012. At the end of the year the BLM had a total of 20,862 active unpatented mining claims in Utah. The number of new claims and total claims in 2012 are both down from 2011 (Opie Abeyta, Utah BLM, written communication, April 2013).

The Utah School and Intuition Trust Lands Administration (SITLA), which manages about 1.8 million hectares (4.4 million acres) of state-owned lands in Utah, issued new leases and/or contracts on 92 tracts in 2012. These leases were divided among the following commodities: metalliferous (49), sand and gravel (13), potash (12), mineral materials (5), gilsonite (4), gemstone/fossil (2), gypsum (2), limestone (1), building stone (1), volcanic (1), oil shale (1), and humic shale (1) (William Stokes, SITLA, written communication, April 2013). SITLA had record total trust assets of just under \$1.5 billion in 2012.



*Figure 2. Value of Utah's annual fuel production in nominal dollars, by industry sector, 2003–2012.*



*Figure 3. Value of Utah's annual nonfuel production in nominal dollars, by industry sector, 2003–2012.*

### National Rankings

Utah ranked 7th nationally in 2012 according to preliminary USGS data for the value of nonfuel mineral production, and accounted for approximately 4.6% of the United States total (USGS, 2013a). According to the USGS preliminary data, Utah's nonfuel mineral production value decreased in 2012 to an estimated \$3.5 billion, significantly less than the record of \$4.6 billion set in 2011 (figure 4). The value of Utah's nonfuel mineral production between 2003 and 2012 has generally increased despite the national economic downturn in 2008, and Utah has been one

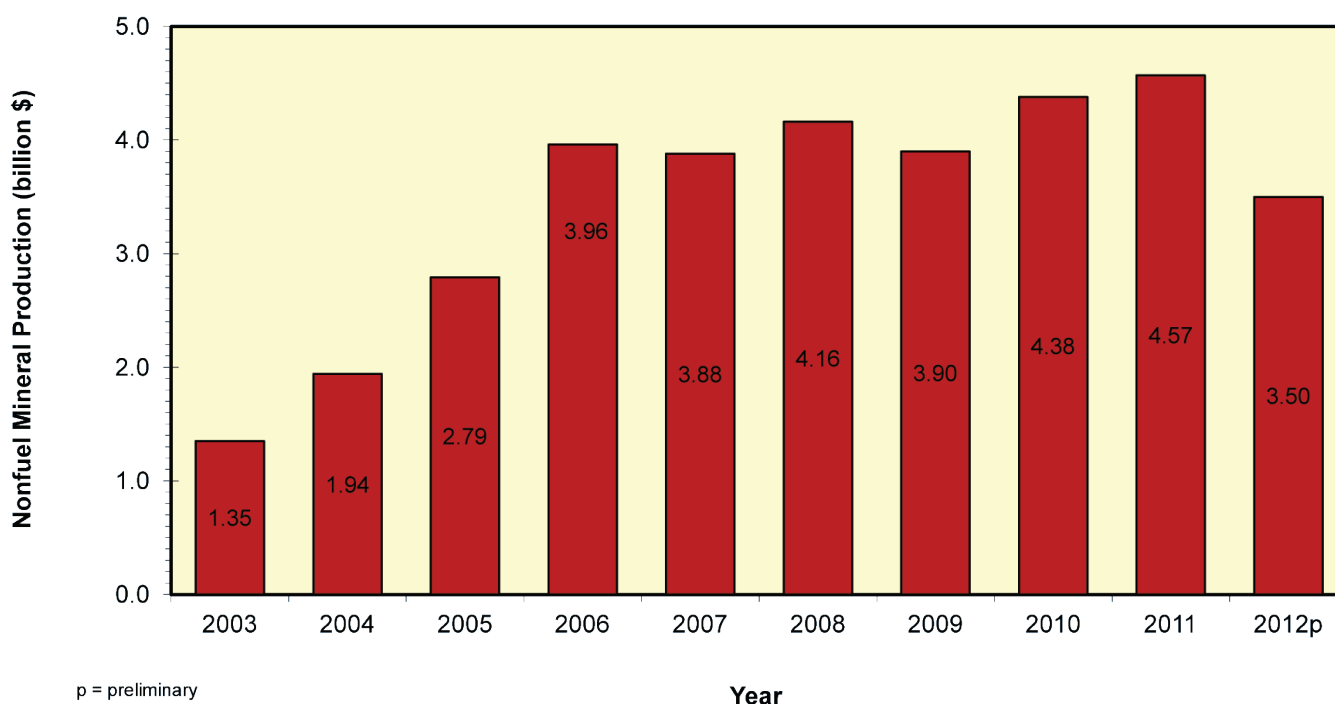
of the top 10 nonfuel mineral-producing states over the past decade. Utah remains the only state in the nation to produce magnesium metal, beryllium concentrates, and gilsonite. In the 2012/2013 Fraser Institute annual survey of mining companies, Utah was ranked as the 9th most favorable state/nation in terms of overall favorability of governmental policy with regard to mining out of the 96 international jurisdictions surveyed (Wilson and others, 2013). Utah ranked 15th nationally for the total amount of coal produced in 2012, according to annual production data from the U.S. EIA (2013a). Utah ranked 11th nationally for the total amount of oil produced in 2012 (U.S. EIA,

**Table 1.** Utah estimated energy and mineral production values in nominal dollars, by energy and mineral industry segment, 2003–2012. Values are in millions.

Year	Base Metals	Industrial Minerals	Precious Metals	Energy Minerals	Oil	Gas	Total Value
2003	\$690	\$555	\$136	\$377	\$378	\$1102	\$3238
2004	\$1136	\$643	\$158	\$367	\$580	\$1457	\$4341
2005	\$2093	\$759	\$209	\$459	\$900	\$2157	\$6577
2006	\$2885	\$811	\$400	\$569	\$1070	\$1912	\$7647
2007	\$2827	\$921	\$322	\$621	\$1221	\$1453	\$7365
2008	\$2900	\$1053	\$390	\$712	\$1908	\$2666	\$9629
2009	\$2,142	\$949	\$635	\$711	\$1152	\$1501	\$7090
2010	\$2,710	\$808	\$651	\$629	\$1679	\$1828	\$8305
2011	\$2625*	\$1156*	\$711*	\$689*	\$2169	\$1777	\$9127
2012	\$2125	\$1209	\$406	\$644	\$2500	\$1330	\$8213

Note: Energy minerals consist of coal and uranium; sulfuric acid has been included in industrial minerals since 2011.

\* = Revised data.

**Figure 4.** Total annual value of Utah's nonfuel mineral production in nominal dollars, 2003–2012. Source: U.S. Geological Survey.

2013b), and 9th (2011 ranking) for the total amount of natural gas produced (U.S. EIA, 2013c).

### Outlook for 2013

Of the nonfuel mineral-producing companies surveyed for this report, 43% of them project duplicating 2012 production in 2013, 37% plan on some production increase, and 20% are projecting less production or are unsure. The massive April 2013 landslide of approximately 150 million t (165 million st) of waste rock from the northeast high-

wall into the bottom of Kennecott Utah Copper's (KUC) Bingham Canyon open pit copper-gold-molybdenum-silver mine will have significant negative consequences on Utah's nonfuel mineral production value for 2013, due to KUC's large percentage of the total value. The mine is expected to produce roughly half of the metals in the upcoming year as it did in 2012. In addition, commodity prices in 2013 are generally headed down from 2012 levels. The combined effects of less metal production and lower commodity prices will likely result in Utah having its lowest nonfuel mineral production value in a decade. The 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 2013. 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 be lower in 2013. Base and precious metals and potash are the focus of a large percentage of the exploration activities planned in 2013.

Utah's coal production is expected to drop slightly in 2013 to 14.7 million t (16.3 million st), while prices should remain steady (figure 5; table 2). Continued coal production declines are mostly demand related. High crude oil prices will spur new development, particularly in Duchesne County, and crude oil production should continue to increase in the next few years. In contrast, the price for natural gas has plummeted and only partially recovered, limiting the economic incentive for expanded development. However, Utah's overall natural gas production continues to increase slightly as associated gas is produced with new crude oil drilling.

## BASE AND PRECIOUS METALS

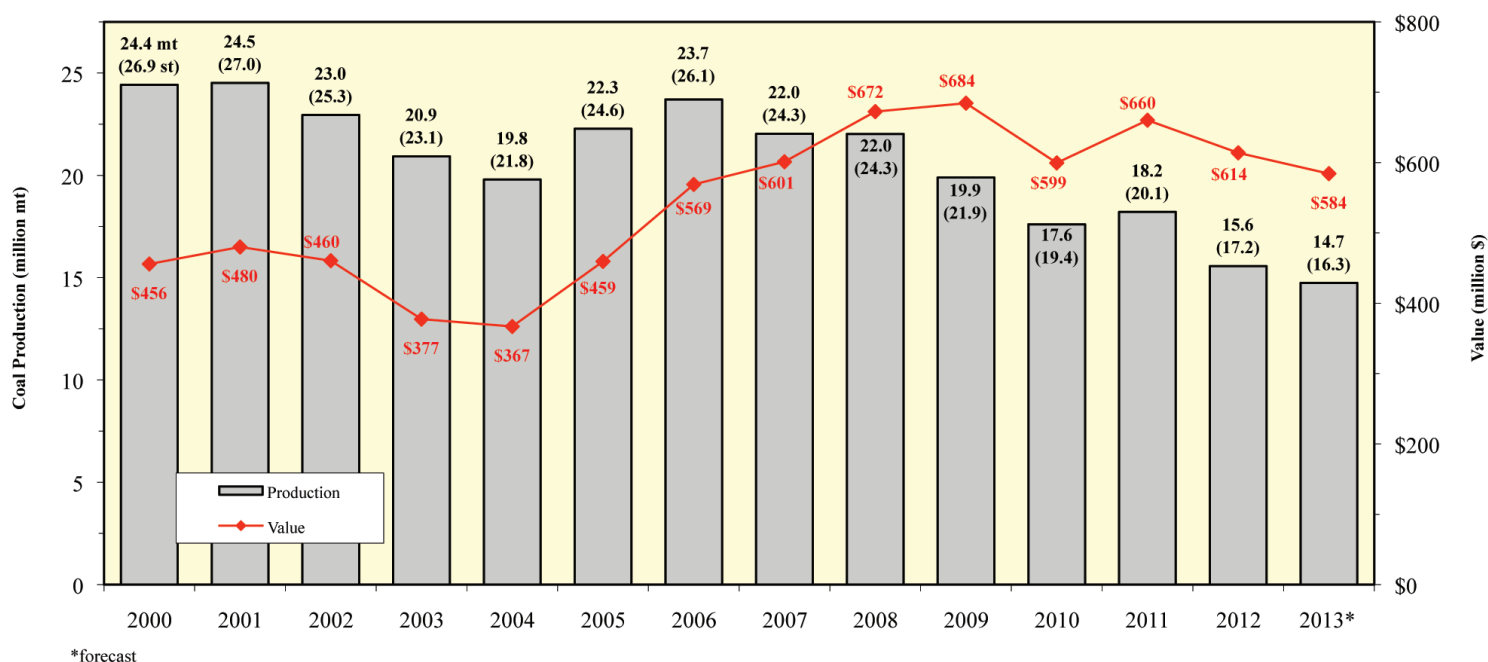
### Production and Values

Base and precious metals produced in Utah during 2012 have an estimated value of \$2.53 billion, which accounts

for 68% of the total value of all nonfuel minerals produced in Utah. Overall base and precious metal production values decreased 24% from 2011. Base metal production value in 2012 is estimated at \$2.12 billion, which was the largest contributor to the total value of all nonfuel minerals produced in Utah, accounting for 57% (figure 3; table 1). Utah's base metal production value decreased by 19% from 2011, because of decreases in the production of copper and molybdenum. Of the total base metal value, copper (65%), magnesium (13%), and molybdenum (13%) together constitute 91%, and iron, beryllium, and vanadium account for the remaining 9%.

Precious metal production value for Utah in 2012 is estimated at \$405.9 million, or 11% of the total value of all nonfuel minerals produced in Utah, and is distributed between gold (84%) and silver (16%) (figure 3; table 1). Precious metal production value decreased by 43% from 2011 to 2012, due to significantly decreased production for both gold and silver.

The vast majority of Utah's copper, gold, and silver, and all of the molybdenum, is produced from KUC's Bingham Canyon mine, located about 32 km (20 mi) southwest of Salt Lake City in Salt Lake County (figure 6). The combined value of metals produced by KUC in 2012 at average prices is estimated at \$2.01 billion, about a 31% decrease from 2011, and was approximately 54% of the total value of all nonfuel minerals produced in Utah. KUC's Bingham Canyon mine was the second largest copper and molybdenum producer in the U.S. in 2012.



**Figure 5.** Utah's annual coal production and value in nominal dollars, 2000–2013.

**Table 2.** Coal production in Utah by coal mine, 2011–2013.

Company	Mine	County	Coalfield	2011		2012		2013*	
				million mt	million st	million mt	million st	million mt	million st
UtahAmerican Energy, Inc. - Murray Energy Corp.	Lila Canyon	Emery	Book Cliffs	142	157	275	304	227	250
Canyon Fuel, LLC- Bowie Resources Partners, LLC	Dugout Canyon	Carbon	Book Cliffs	2173	2395	1441	1588	454	500
	Skyline #3	Carbon	Wasatch Plateau	2676	2950	1773	1954	1996	2200
	SUFCO	Sevier	Wasatch Plateau	5895	6498	5126	5651	5352	5900
Castle Valley Mining - Rhino Resources	Castle Valley #4	Emery	Wasatch Plateau	537	592	911	1004	816	900
Energy West Mining Co.	Deer Creek	Emery	Wasatch Plateau	2851	3143	2989	3295	2722	3000
Hidden Splendor Resources, Inc. - America West Resources, Inc.	Horizon	Carbon	Wasatch Plateau	336	370	191	210	--	--
West Ridge Resources, Inc. - UtahAmerican Energy, Inc. - Murray Energy	West Ridge	Carbon	Book Cliffs	3235	3566	2339	2579	2540	2800
Alton Coal Development	Coal Hollow	Kane	Alton	365	403	517	570	635	700
<b>Total</b>				<b>18,210</b>	<b>20,073</b>	<b>15,563</b>	<b>17,155</b>	<b>14,742</b>	<b>16,250</b>

Source: UGS coal company questionnaires

\*Forecast

## Copper

In 2012, copper was the largest contributor to the value of nonfuel minerals in Utah, having an estimated value over \$1.38 billion, about a 23% decrease from 2011. KUC's Bingham Canyon mine produced the majority of copper in Utah in 2012 at approximately 163,200 t (180,000 st), a significant decrease of about 31,800 t (35,000 st) from 2011 (Rio Tinto, 2013). The average copper price decreased about 9% from 2011 to \$8.16/kg (\$3.70/lb) (USGS, 2013a), and KUC's production for 2012 has an estimated value of \$1.33 billion, which is a decrease of about 24% from 2011.

Lisbon Valley Mining Company operates a copper mine and processing facility about 48 km (30 mi) southeast of Moab in San Juan County (figure 6). About 5171 t (5700 st) of copper was produced by the company in 2012, slightly less than in 2011, with an estimated value over \$42 million at the 2012 average copper price (USGS, 2013a). C.S. Mining, LLC produced approximately another 512 t (565 st) of copper in 2012 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, refrigerator, and heating systems.

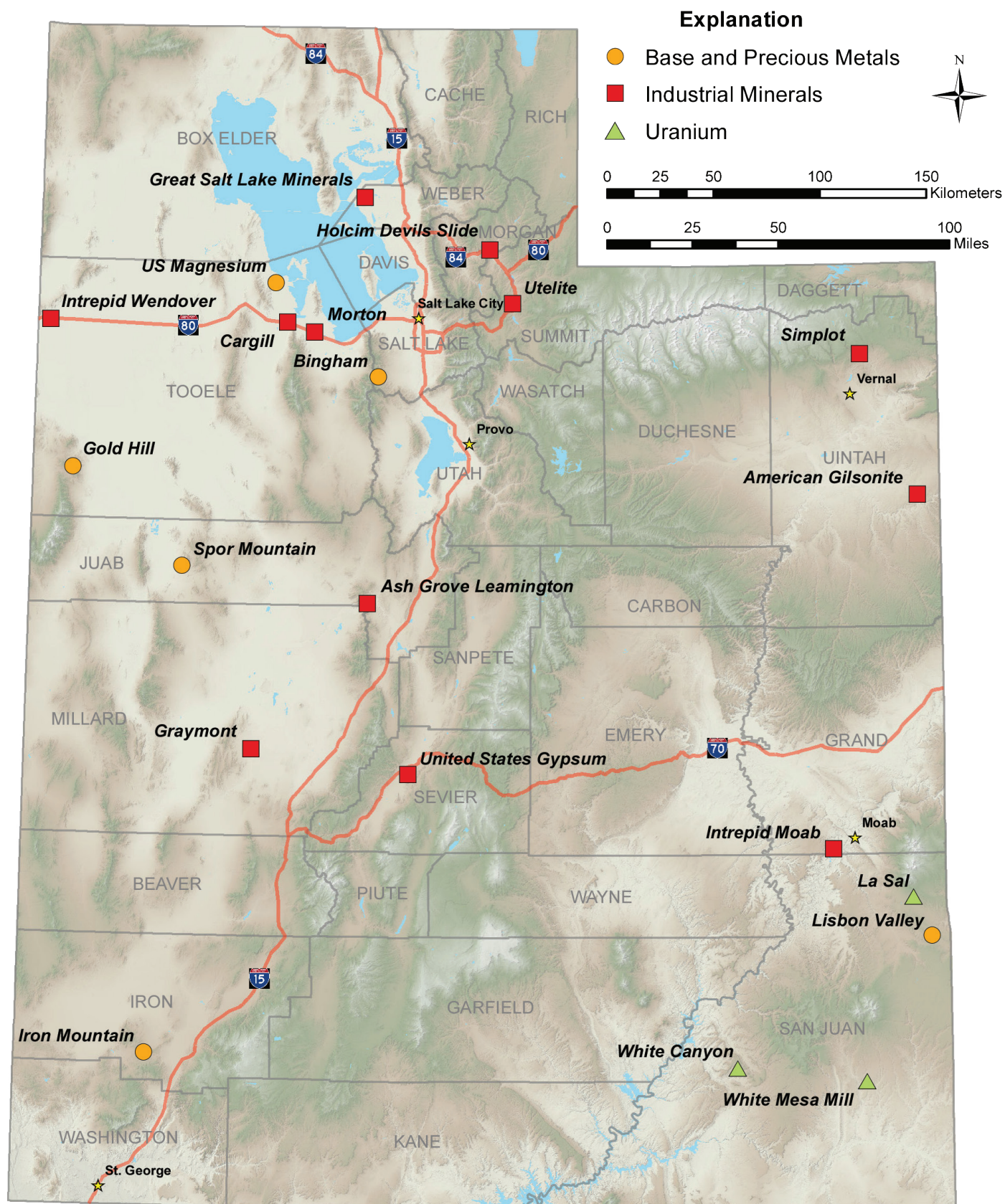
## Magnesium

The only facility producing magnesium from a primary source in the United States is located about 96 km (60 mi) west of Salt Lake City at Rowley in Tooele County (figure 6), and is operated by U.S. Magnesium, LLC. Magnesium chloride concentrate is produced from Great Salt Lake brines through evaporation and converted to magnesium metal by an electrolytic process. USGS (2013a) reports that annual magnesium production capacity at U.S. Magnesium's plant is 63,500 t (70,000 st). The price for magnesium metal increased slightly from 2011, averaging \$4.85/kg (\$2.20/lb) in 2012 (USGS, 2013a). Utah's 2012 magnesium production is valued around \$308 million, assuming production at full capacity, ranking it second as a contributor to Utah's base metal values in 2012. 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 (43%), structural use in castings and wrought products (40%), and for desulfurization of iron and steel (11%) (USGS, 2013a).

## Molybdenum

Utah's molybdenum production in 2012 came solely





**Figure 6.** Base and precious metals, selected industrial minerals, and uranium production locations in Utah during 2012.



from KUC's Bingham Canyon mine, where it was recovered as a byproduct from the copper operation. Approximately 9400 t (10,362 st) of molybdenum was produced in 2012, a large decrease of about 31% from 2011 (Rio Tinto, 2013). Molybdenum's average price dropped about 14% from 2011 to \$29.20/kg (\$13.24/lb) (USGS, 2013a). Utah's molybdenum production in 2012 is valued at approximately \$274 million using the average 2012 price. Molybdenum production value was about 41% lower than in 2011, due to the decrease in production and price. Molybdenum ranked third as a contributor to Utah's base metal values in 2012. In 2012, molybdenum concentrate in the U.S. was produced by 12 mines, as either a primary product or byproduct, and was valued at about \$1.7 billion. Molybdenum is primarily used in alloys with other metals by iron, steel, and other producers that account for about 76% of the molybdenum consumed (USGS, 2013a).

## Iron Ore

Iron ore in Utah is solely produced by CML Metals, Incorporated from their Iron Mountain project, which is a re-development of the Comstock/Mountain Lion iron mine located about 30 km (19 mi) west of Cedar City in Iron County (figure 6). In 2012, CML produced approximately 1,436,451 t (1,583,400 st) of mostly run-of-mine iron ore up to 54% iron and lesser amounts of concentrate up to 67% iron (CML Metals, 2012). Iron ore production increased about 11% from 2011 to 2012. Estimated value of the iron ore at approximately \$110/t (\$100/st) is around \$158 million, which is an increase of about 32% from 2011. Iron ore production ranks fourth in contribution to Utah's 2012 base metal production values. Iron ore from the Iron Mountain project is transported by rail to a port in Southern California and shipped overseas.

## 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 68 km (42 mi) northwest of Delta in Juab County (figure 6). Materion operates a mill 18 km (11 mi) north of Delta in Millard County, which is the nation's sole source of beryllium concentrate, where bertrandite ore and imported beryl are processed 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 into beryllium-copper master alloy, metal, and oxide (USGS, 2013a). About 73,000 t (80,500 st) of bertrandite ore was mined in 2012 from the Topaz mine at Spor Mountain. Beryllium concentrate production from Utah in 2012 is estimated to be 206 t (228 st), roughly the same as 2011, having a value of approximately \$20 million. The average beryllium price for 2012 was slightly higher

than in 2011 at \$461/kg (\$209/lb) (USGS, 2013a), which resulted in an increase of about 3.5% in value over 2011. Beryllium ranked fifth as a contributor to Utah's 2012 base metal values. Beryllium is 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 applications.

## Vanadium

Vanadium, in the form of vanadium pentoxide ( $\text{V}_2\text{O}_5$ ), is a byproduct of uranium mining and milling at Energy Fuel's White Mesa mill about 10 km (6 mi) south of Blanding in San Juan County (figure 6). In 2012, Energy Fuels produced approximately 821,500 kg (1,811,200 lb) of  $\text{V}_2\text{O}_5$  having a value of approximately \$12 million, from the Beaver and Pandora mines uranium ore. The average vanadium price in 2012 was \$14.37/kg (\$6.52/lb) (USGS, 2013a), remaining steady from 2011. Vanadium production value increased significantly in 2012 by about 43% over the value in 2011, and was due to an approximate 40% increase in production over 2011. Vanadium ranked sixth as a contributor to Utah's 2012 base metal values. Metallurgical use by the steel industry as an alloying agent is responsible for about 93% of domestic vanadium consumption (USGS, 2013a).

## Gold

In 2012, approximately 201,000 troy ounces (oz) of gold was produced in Utah, which was about a 48% decrease (185,000 troy oz) from 2011 (Rio Tinto, 2013). KUC mines most of this gold at its Bingham Canyon mine, where it is recovered as a byproduct from the copper operation. About 1000 troy oz of the total gold produced came from residual leaching of existing heaps at KUC's Barney's Canyon mine, which ceased active mining in 2001 after ore exhaustion, and is located 4 km (2.5 mi) north of the Bingham Canyon operation. The average gold price in 2012 was \$1700/troy oz, an increase of about 8% from 2011 (USGS, 2013a). Utah's gold production at the 2012 average price has an estimated value of \$342 million, about a 44% decrease in value from 2011. Small quantities of gold and silver may have been produced by other small Utah mines, but production may not be reported and would not make any significant impact on the total amount of gold and silver produced in Utah.

## Silver

KUC produced most of Utah's silver in 2012 from the Bingham Canyon mine, where it is also recovered as a byproduct from the copper operation. Total silver production in 2012 amounted to approximately 2,126,680 troy oz, which was about a 28% decrease (849,320 troy oz) from

2011 (Rio Tinto, 2013). In 2012, C.S. Mining produced approximately 40,680 troy oz of silver from its Hidden Treasure mine in Beaver County. The average silver price in 2012 was \$30/troy oz, a decrease of about 15% from 2011 (USGS, 2013a). Utah's silver production at the 2012 average price has an estimated value of \$64 million, about a 40% decrease in value from 2011.

## Exploration and Development Activity

Metals had an off year in 2012 with copper, molybdenum, and silver prices slipping, compounded by significantly decreased Utah production. Base metal exploration in 2012 was dominated by major companies doing brownfield exploration in the Bingham, Tintic, and Drum (Detroit) mining districts.

The escalating gold price in 2012 prompted renewed exploration activity for that metal in Utah. Precious metal exploration was also driven by recent important sediment-hosted gold discoveries in the Basin and Range of eastern Nevada (e.g., Long Canyon and Kinsley Mountain, Elko County). Gold-silver exploration is being carried out by major gold-silver producers and junior exploration companies, as well as local prospectors.

### Bingham Canyon

KUC's Bingham Canyon porphyry copper-gold-molybdenum-silver mine (figure 6), Salt Lake County, produced its 3 billionth short ton of porphyry ore in 2012, continuing a remarkable run of over 100 years of open pit copper mining. Bingham remained the second largest annual producer of both copper and molybdenum in the U.S. In June 2012, the \$660 million Cornerstone push-back was approved to extend the Bingham Canyon mine life from 2018 to 2029. This project involves pushing back the south pit wall about 300 m (1000 ft) to access an additional 515 million t (568 million st) of 0.79% copper equivalent ore.

Copper, molybdenum, gold, and silver production from Bingham were all down in 2012 from 2011 due to lower ore tonnages mined. Furthermore, copper, molybdenum, and silver prices were also down while only gold prices rose. Consequently gross sales revenue was down to \$2.4 billion in 2012.

KUC began construction of a \$340 million molybdenum autoclave process (MAP) facility in 2011. The new MAP facility will have the capacity to produce 13.6 million kg (30 million lb) of molybdenum products and an additional 4090 kg (9000 lb) of rhenium per year. The MAP facility is due to come online in mid-2014 followed by a one-year shakedown period to reach full capacity. Ultimately the plant could produce 10% of the world's molybdenum.

Although KUC's Barney's Canyon gold mine ceased min-

ing in 2001, the operation continues to recover minor amounts of gold from the old heap leach pads. In 2012, production was approximately 1000 oz.

Kennecott Exploration Company (KEC) continued an aggressive brownfield, near-mine exploration drilling program in the Oquirrh Mountains in 2012. An additional 11 deep core holes (including deflections) totaling 12,294 m (40,335 ft) were completed in the Bingham area (Russ Franklin, KEC, written communication, May 2013).

### 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, San Juan County. The company began copper mine (figure 6) development in 2005 with plant construction completed in 2006. Following some startup problems, Lisbon Valley Mining Company successfully restarted mining operations in 2009. Mine production in 2012 was similar to 2010 and 2011, holding steady at about 2.41 million t (2.65 million st) averaging 0.46% copper delivered to the heap leach pads (Lantz Indergard, Lisbon Valley Mining Company, written communication, April 2013).

### Iron Springs

The CML mine (formerly the Comstock-Mountain Lion) at Iron Mountain, Iron County (figure 6), was acquired by Palladon Iron Corporation in 2005, and restructured into CML Metals Corporation in early 2010. The iron ore occurs as massive magnetite skarn/replacement deposits adjacent to Miocene laccoliths. Open pit mining was initiated by Palladon in 2008, but ceased in 2009 due to instability in the iron ore market and logistical problems. In 2009, Palladon completed a Canadian NI 43-101 compliant resource estimate on the CML deposit showing a resource of 28.4 million t (31.4 million st) averaging 48.6% iron (SRK Consulting, 2009). Mining was restarted by CML in July 2010 and run-of-mine ore was shipped out of the new rail load-out facility at the mine by the Union Pacific Railroad. The concentrator was completed in early 2012 and operated in break-in capacity throughout 2012, suffering through concentrate dewatering difficulties. CML mined approximately 1.4 million t (1.6 million st) in 2012 and is still optimizing the concentrator to produce a high-grade iron concentrate at a rate in excess of 1.8 million t (2 million st) per year.

CML also completed nine drill holes in 2012, twinning old U.S. Steel holes in the Rex deposit to verify the historic resource of approximately 73.4 million t (80.9 million st) of 39% iron. The completion of a feasibility study on the Rex deposit is planned for 2013.

## Drum Mountains

The Drum Mountains (Detroit mining district) became the most competitive metal exploration area in the state in 2012. Freeport-McMoRan Exploration Corporation acquired about 413 ha (1020 acres) of SITLA land, roughly 405 ha (1000 acres) of patented mining claims, and staked an additional 395 lode claims in the copper-gold heart of the old mining district. The Steele family also has about 70 claims in this area.

Newmont Mining Corporation signed an earn-in agreement with Renaissance Gold, Incorporated on the Wildcat sedimentary rock-hosted gold property in the northern Drum Mountains, Juab County (figure 7). The property consists of over 200 unpatented mining claims. The property was explored by Gold Fields Mining Corporation in the early 1990s. Gold Fields' drilling cut intervals of up to 22.9 m (75 ft) of 1.27 ppm gold (hole DM-27). Newmont completed four reverse-circulation holes in 2011 and approximately 12 more in 2012 totaling 2751 m (9025 ft) (Rendy Keaten, Newmont Mining Corporation, written communication, May 2013). Golden Dragon Capital also holds about 38 claims in this area.

Anglo Gold Ashanti USA (184 claims), C.S. Mining (226 claims), Golden Dragon (44 claims), and North Exploration (10 claims) have acquired land positions in the southern part of the Detroit district near the historic Drum distal disseminated silver-gold open pits in Millard County.

## Rocky and Beaver Lake Districts

C.S. Mining controls a series of small copper deposits in the Rocky and Beaver Lake mining districts (figure 7) in Beaver County. These properties host seven partially delineated prograde copper skarn and copper breccia pipe deposits. In 2009, a flotation mill was completed and open pit mining started on the Hidden Treasure copper skarn. The mill began production at 1100 t per day (1200 st/day) in May 2009 and produced a very 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 experienced less than 20% copper recovery due to the mixed oxide-sulfide nature of the skarn ore and operations were halted near the end of 2009. The mine and mill were restarted in September 2012 and 187,358 t (206,527 st) of ore was mined from the Hidden Treasure copper skarn in 2012. C.S. Mining produced roughly 18 t (20 st) of concentrate per day for shipment in 2012 to the Bingham smelter. The concentrate is estimated to average about 25% copper, 600 ppm silver, and 3 ppm gold.

## Tecoma District

In 2010, the TUG distal disseminated silver-gold deposit

in the Tecoma district (figure 7) of westernmost Box Elder County was optioned by West Kirkland Mining (USA) Limited from Newmont. The TUG deposit has a historic open-pit resource of about 1.4 t (1.5 million st) averaging 1.71 ppm gold and 100 ppm silver, but recent drilling has increased the size to an inferred resource of approximately 27 million t (30 million st) at 0.49 ppm gold and 15.9 ppm silver (Selway and others, 2012).

## Goldstrike District

Cadillac Mining Corporation acquired 1540 ha (3800 acres) covering the historic mining area of the Goldstrike sedimentary rock-hosted gold-silver mining district, Washington County (figure 7). Production from Goldstrike in the 1980s and 1990s totaled approximately 210,000 oz of gold and 198,000 oz of silver. Cadillac compiled and digitized the historic exploration/mining data on the district in 2011 and drilled three holes from a single pad on the Hamburg Extension target later that year. Two of these three initial reverse-circulation holes (GS11-02 and 03), totalling 567 m (1860 ft), intersected 1.08 ppm gold over 73.1 m (240 ft) and 1.25 g ppm gold over 82.3 m (270 ft). Several follow-up holes in 2012 also intersected mineralization including GS12-07, which cut 30.2 m (99 ft) of 1.56 ppm gold and 3.8 ppm silver, and GS12-08, which intersected 30.8 m (101 ft) of 2.05 ppm gold and 4.3 ppm silver.

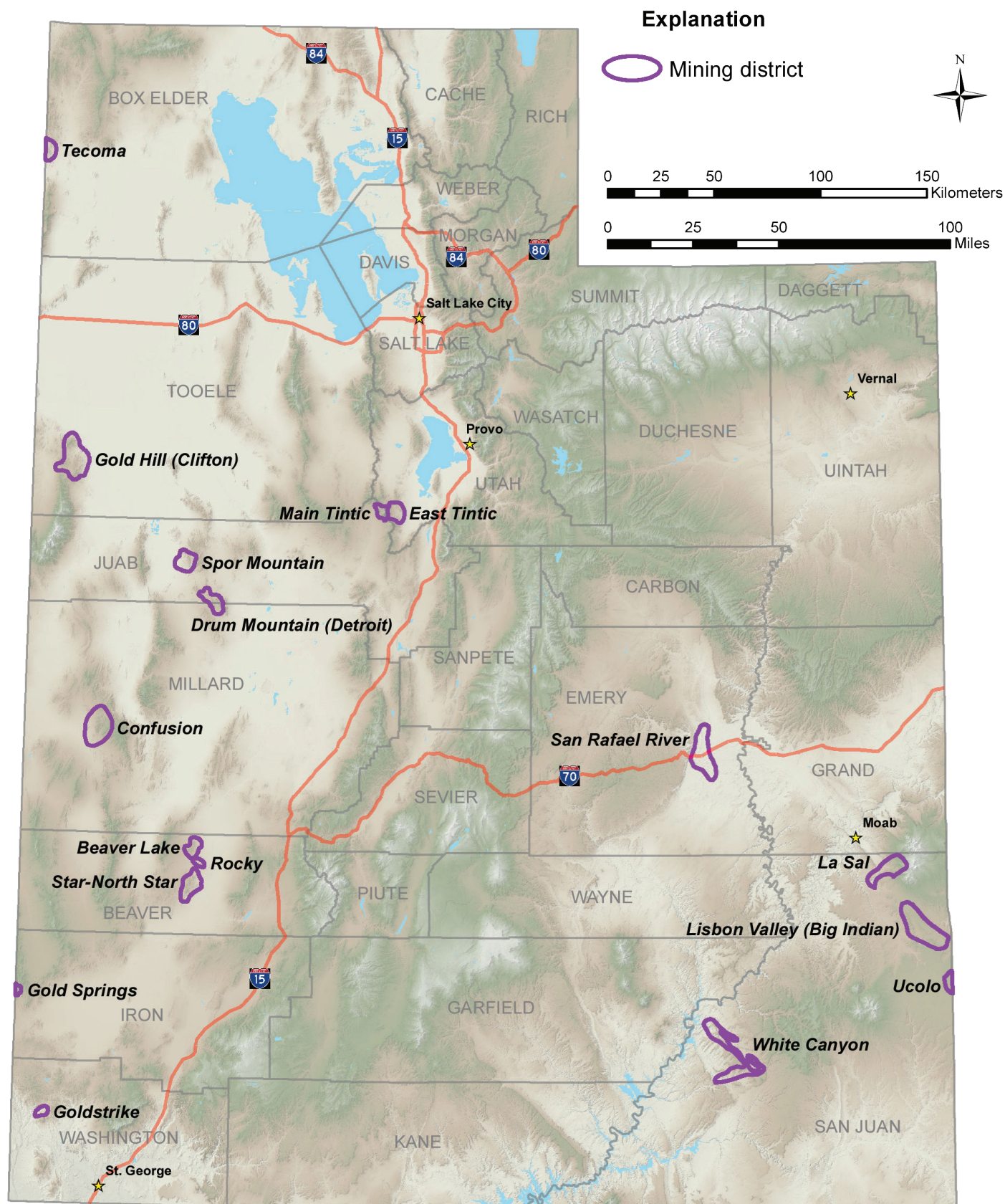
## Confusion Range

In 2012, Pine Cliff Energy Limited acquired 100% interest in the 930 ha (2300 acres) Kings Canyon sedimentary rock-hosted gold-silver property in western Millard County (figure 7). The property was explored in the early 1990s, primarily by Crown Resources. The property contains several known gold zones; the largest defined resource is in the Crown zone, about 7.3 million t (7.9 million st) averaging roughly 0.93 ppm gold (Krahulec, 2011). Geomark is continuing drilling to expand Kings Canyon and a more poorly defined Royal resource, with intersections including KC12-17 in the Royal zone of 33.5 m (110 ft) of 1.09 ppm gold.

## Gold Springs District

The Gold Spring mining district is located in extreme western Iron County, southwestern Utah (figure 7). The district is a small historic low-sulfidation, epithermal, gold-silver quartz-adularia-calcite vein/stockwork district. High Desert Gold Corporation controls a 2430 ha (6000 acre) block of ground in the Gold Springs district. High Desert Gold announced an initial inferred resource on the Jumbo gold-silver stockwork of 9,392,155 t (10,353,079 st) at 0.57 ppm gold and 12.90 ppm silver (Katsura and Armitage, 2012). A follow-up four to eight hole reverse-circulation drilling program on the Jumbo zone is scheduled to begin in April 2013.





**Figure 7.** Base and precious metals, and uranium exploration and development activity locations in Utah during 2012.



## Gold Hill District

Clifton Mining Company and Desert Hawk Gold Corporation agreed in 2009 to jointly develop Clifton's mineral properties in the Gold Hill district (figure 7) in western Tooele County. Desert Hawk plans a heap leach operation at the Kiewit low-sulfidation, quartz-carbonate-adularia stockwork gold deposit. The Kiewit deposit is known to contain a crudely estimated 1.5 million t (1.7 million st) averaging about 1 ppm gold. Permitting of the Kiewit open pit and cyanide heap leach operation is underway.

## Tintic District

Andover Ventures, Incorporated purchased 78.5% of Chief Consolidated Mining Company in 2008. Chief Consolidated's main assets are properties in the East Tintic district (figure 7), Utah County. Andover has released an indicated resource for the Burgin Extension deposit containing 834,500 t (920,000 st) at 0.86 ppm gold, 249 ppm silver, 9.3% lead, and 3.5% zinc with an additional inferred resource of 1,231,000 t (1,357,000 st) at 0.45 ppm gold, 299 ppm silver, 14.4% lead, and 5.2% zinc (Tietz and others, 2011).

In addition, KEC, through a joint venture with Andover, acquired a porphyry copper lithocap target on Big Hill near the center of the East Tintic district. 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 reverse-circulation holes, totaling 1341 m (4311 ft), were precollared in 2011 and two of these holes (figure 8), totaling 1572 m (5159 ft), were core drilled to completion in 2012 (Russ Franklin, KEC, written communication, May 2013).

Quaterra Resources, Incorporated acquired about 1300 ha (3200 acres) of patented and unpatented mining claims encompassing the Southwest Tintic porphyry copper system, Juab County, in 2007. The property hosts a known historic resource of approximately 360 million t (400 million st) of 0.33% copper and 0.01% molybdenum (Krauhlec and Briggs, 2006). This property was joint-ventured with Freeport-McMoRan Exploration Corporation in 2009, and Freeport began an integrated program of geological mapping, geochemical sampling, geophysical surveying, and drilled seven holes in 2010-11. No additional drilling was completed in 2012.

## Star District

Firestrike Resources Limited acquired a property position in the eastern Star Range, Beaver County in 2012 (figure 7). Following an initial dump rock sampling program they drilled 19 shallow, close-spaced holes totaling about 1994

m (6542 ft). The best hole (FSRC12-19) cut 13.4 m (44 ft) of 0.72 ppm gold beginning at a depth of just 3 m (13 ft) apparently in a ferruginous fissure zone in the Oligocene Vicksburg quartz monzonite stock.

## Spor Mountain

Avalon Rare Metals controls 383 unpatented lode claims (3202 ha; 7900 acres) on a Spor Mountain rare metal prospect, Juab County (figure 7). Geologic and ground magnetic surveys were completed in 2011. In 2012, Avalon completed four core holes totaling 1236 m (4055 ft) at Spor Mountain. All four holes reportedly encountered



**Figure 8.** Rig working on one of Kennecott Exploration Company's deep porphyry copper exploration holes on Big Hill in the East Tintic mining district, Utah County (photograph courtesy of Radoslav Kehayov).

intense alteration, brecciation, and faulting typically found near hydrothermal mineralization.

IBC Advanced Alloys Corporation acquired 371 claims adjacent to Materion's (Brush-Wellman's) Spor Mountain beryllium mine, the largest beryllium producer in the world. IBC completed a 7495-line-km (4657-line-mi) airborne magnetic and radiometric survey in 2010, which defined several potential targets. In 2011, IBC began drill testing these targets, completing an east-west fence of 35 reverse-circulation holes totaling 5500 m (18,040 ft) south of Materion's property. Preliminary analytical results released in mid-2012 appeared unfavorable with the best intercept being just 617 ppm beryllium.

### **Miscellaneous Base Metal and Precious Metal Developments**

Newmont Mining Corporation drilled five holes for gold at the Cina mine in north-central Iron County in 2011. The Cina mine is a high-level, epithermal mercury-sulfur system. Analytical results showed very little gold and the property was dropped. Newmont also has two additional sedimentary rock-hosted gold claim blocks in the northern Pilot Range and Goose Creek Mountains of extreme western Box Elder County.

In 2012, Kinross Gold USA, Incorporated staked 305 claims in the Fortuna mining district, Beaver County. The Fortuna district hosts Miocene low-sulfidation, epithermal, gold-silver quartz-adularia-calcite veins. Kinross also acquired a core block of 25 lode claims and a block of patented mining claims covering an additional 105 ha (260 acres) to the south. Drilling is anticipated in 2013.

During 2012, Eurasian Minerals (Bronco Creek) staked 238 lode claims at the Sand Pass distal disseminated silver-gold prospect in the northern House Range, Juab County. Eurasian also acquired a small patented claim block in the northern Ophir mining district, Tooele County.

Grand Central controls a large 1934-ha (4779-acre) Cave mine property position in the Bradshaw silver-gold-lead district of the southern Mineral Mountains, Beaver County. The Cave mine targets include copper-gold skarns and high-grade, precious metal-rich, polymetallic carbonate replacement deposits, like the old Cave mine itself. Initial work included surface and underground geological mapping and geochemical sampling along with a 150-line-km (93-line-mi) ground magnetometer survey and some IP surveying.

The Coyote Knolls low-sulfidation silver-gold deposit, Juab County, was acquired by Amnor Energy Corporation in 2012. Coyote Knolls hosts a small, partly drill-defined resource estimated at about 45,000 t (50,000 st) averaging roughly 150 ppm silver and 1 ppm gold developed on a

narrow, steeply dipping, high-grade vein/pebble dike that is open at depth. Amnor Energy Corporation began mining operations and built a small, off-site gravity mill west of Eureka. The mill operated by fine crushing and using shaker gravity concentrating tables to produce a concentrate. The whole operation was shut down after only a few weeks of operation due to high levels of mining dilution.

## **INDUSTRIAL MINERALS**

### **Production and Values**

Industrial minerals production in Utah in 2012 had an estimated value of \$1.2 billion and was second at 32% in contribution to the total value of nonfuel minerals produced in Utah (figure 3; table 1). Industrial minerals value in 2012 was approximately equal to the record-breaking value set in 2011. Industrial minerals production value remained steady from 2011 due to continued higher prices and production for some commodities.

The largest overall contributors to the value of industrial minerals production in Utah during 2012 were the brine-derived products of potash, salt, and magnesium chloride, having a combined value of \$421.2 million. This value represented 35% of total industrial mineral value in 2012, and was an 8% increase over 2011. 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 \$201 million. The value of this commodity group accounted for 17% of total industrial mineral value in 2012, and decreased 5% from 2011. The third-largest overall contribution to the value of industrial minerals production came from Portland cement and lime products, having a combined value of \$194 million that accounts for 16% of total industrial mineral value in 2012, an increase of 10% in value over 2011. These three commodity groups contributed 68% of the total value of industrial minerals produced in Utah during 2012. The remaining 32% of Utah's total industrial mineral value came from, in decreasing order of value, phosphate, sulfuric acid, gilsonite, clays, expanded shale, and gypsum.

### **Potash, Salt, and Magnesium Chloride**

The brine-derived commodities produced from Great Salt Lake and other deposits were important contributors to the value of Utah's industrial mineral production in 2012, and consisted of 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, were produced by operations in other parts of the state. Small amounts of concentrated magnesium brine for use in nutritional



supplements were produced by Mineral Resources International, Incorporated (NorthShore Limited Partnership).

Potash production in Utah was over 410,000 t (450,000 st) in 2012, and was the largest contributor to the value of the brine-derived commodities group. The 2012 value of potash produced in Utah was approximately \$233 million, an increase of about 6% from 2011 that was due to increases in production of potassium sulfate and increases in the price of potash. Great Salt Lake Minerals Corporation produces the potassium sulfate variety, whereas Intrepid Potash-Wendover and Intrepid Potash-Moab produce the potassium chloride variety (figure 6).

Utah's salt production in 2012 was approximately 2.89 million t (3.18 million st), an increase of about 10% from 2011. This salt production was valued at approximately \$154.5 million, an increase of about 8% over 2011 that was due to higher production in 2012, since prices remained steady from 2011. Some 84% of this salt was produced from Great Salt Lake brine by four operators who were, in descending order of production, (1) Great Salt Lake Minerals Corporation, (2) Cargill Salt Company, (3) Morton International, and (4) U.S. Magnesium (figure 6). The remaining 16% came from another three operators who were, in descending order of production, (1) Redmond Minerals, Incorporated near Redmond in Sanpete County, (2) Intrepid Potash-Wendover near Wendover in Tooele County, and (3) Intrepid Potash-Moab near Moab in Grand County.

Magnesium chloride production in Utah was approximately 770,000 t (850,000 st) in 2012, about a 25% increase from 2011. Magnesium chloride prices remained steady from 2011, and production value of magnesium chloride was estimated at \$34 million, an increase of about 25% from 2011 to 2012. Great Salt Lake Minerals Corporation on the east side of Great Salt Lake and Intrepid Potash-Wendover produced the magnesium chloride.

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

Sand and gravel, crushed stone, and dimension stone are produced by commercial operators as well as various county, state, and federal agencies. Due to the large number of producers in this commodity group, it is not practical for the UGS to send annual production questionnaires to all of the operators. However, the UGS does compile data from selected operators to track these commodities, and uses USGS data for production and value figures. In Utah during 2012, approximately 24.3 million t (26.8 million st) of sand and gravel was produced, valued at \$146 million (USGS, 2013b). About 6.86 million t (7.56 million st) of crushed stone having a value of \$54.3 million (USGS, 2013b), and an estimated 8200 t (9000 st) of dimension stone having a value of approximately \$0.7 million, was

produced in 2012. Production value for the commodity group in 2012 is approximately \$201 million, about a 5% decrease from 2011. Unit price for sand and gravel and crushed stone remained steady from 2011, and the value decrease resulted from slightly lower production of these two commodities.

### **Portland Cement, Lime, and Limestone**

Two companies, Ash Grove Cement Company and Holcim, Incorporated, produced Portland cement in Utah during 2012, which amounted to over 1 million t (1.1 million st) having a value over \$100 million. Ash Grove Cement Company operates the Leamington quarry and plant located east of Leamington in Juab County, and Holcim operates the Devils Slide quarry and plant located east of Morgan in Morgan County (figure 6). Portland cement production in 2012 increased about 3% over 2011, resulting in a slight value increase for 2012 as well. However, production still remained below the combined potential capacity of the companies' plants of 1.4 million t (1.5 million st) of cement annually. Along with limestone, Ash Grove Cement and Holcim also mine small amounts of sandstone, clay, and shale that are used in cement manufacturing.

Lime in 2012 was produced solely by Graymont Western U.S., Incorporated. In the past Lhoist North America has produced dolomitic lime, but their quarry and plant in Tooele County have been idle since 2008. Lime production increased approximately 3% from 2011 to 2012. Graymont Western U.S. produces high-calcium quicklime and dolomitic quicklime from their quarry and plant in the Cricket Mountains about 56 km (35 mi) southwest of Delta in Millard County (figure 6). The annual production capacity when both plants are in operation is over 0.9 million t (1.0 million st).

Limestone production for 2012 amounted to approximately 3.3 million t (3.6 million st). The three operators responsible for most of this production were, in decreasing order of production, (1) Graymont Western U.S., Incorporated, (2) Ash Grove Cement Company, and (3) Holcim, Incorporated. Cotter Corporation in San Juan County produced a lesser amount of limestone for flue-gas desulfurization in 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."

### **Phosphate**

Simplot Phosphates continues to be the only active phosphate producer in Utah. The company's phosphate operation is located 19 km (12 mi) north of Vernal in Uintah County (figures 6 and 9). In 2012, the mine produced



**Figure 9.** Simplot Phosphates operation north of Vernal in Uintah County, Utah.

approximately 3.5 million t (3.9 million st) of ore, about 7% less than in 2011. The ore yields roughly 1.2 million t (1.3 million st) of phosphate concentrate (P2O5) after processing. The concentrate is then transported in slurry form through a 155 km (96 mi) underground pipeline to the company's 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, 2013a).

### Sulfuric Acid

In 2012, KUC's Bingham Canyon mine generated approximately 725,755 t (800,000 st) of sulfuric acid ( $\text{H}_2\text{SO}_4$ ), slightly less than in 2011, as a byproduct of the copper-gold-silver smelting process. Although sulfuric acid has been recovered at the Bingham copper smelter since 1917, this is just the second year its dollar value is included in the UGS production survey, now ranking it 5th in contribution to the value of Utah industrial minerals. In 2012, sulfuric acid prices averaged about \$152/t (\$138/st), suggesting a very approximate total value of about \$110 million. 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.

### Gilsonite

Gilsonite is a shiny, black, solid hydrocarbon that forms 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 2012, American Gilsonite Com-

pany (figure 6) and Ziegler Chemical and Mineral Company both mined and processed gilsonite at their operations in southeastern Uintah County. Gilsonite production has remained steady from 2011 to 2012 at about 74,400 t (82,000 st), with American Gilsonite Company responsible for most of that production. Gilsonite production in 2012 is valued at approximately \$88.9 million, at an average price of \$1198.87/t (\$1087.61/st) (Office of Natural Resources Revenue, 2013), an increase of about 35% from 2011 to 2012 due to the significant price increase. Utah is the only place in the world that contains large economic deposits of gilsonite, and it has been shipped worldwide for use in a large number of diverse products ranging from asphalt paving mixes and coating, inks and paints, to oil and gas well drilling (Boden and Tripp, 2012).

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

Production of bentonite, common clay, and high-alumina clay in Utah during 2012 amounted to approximately 248,200 t (273,600 st), about the same production as in 2011. These commodities are produced by many small and large mines, often on an intermittent basis. Bentonite was produced by two companies, Western Clay Company and Redmond Minerals, Incorporated, which together produced about 70% of the total production. Uses for bentonite include well drilling and foundry operations, various civil engineering applications, and as litter-box filler. The largest producers of common clay and high-alumina clay were Interstate Brick Company, and Holcim, Incorporated, respectively, which together produced the remaining 30% of the total production. The manufacturing of bricks was the primary use for common clay, and high-alumina clay was used for manufacturing of Portland cement.



## Expanded Shale

Expanded shale in Utah is solely produced by Utelite, Incorporated at their quarry and plant near Wanship in Summit County (figure 6). The company produced approximately 108,000 t (119,000 st) in 2012, a decrease of about 14% from 2011 production. Expanded shale is a lightweight aggregate, sometimes referred to as “bloated shale,” mainly used by the construction industry. It is produced by heating high-purity shale from the Cretaceous Frontier Formation to about 1100° C (2000° F), causing it to expand and vitrify. The resulting aggregate is durable, inert, uniform in size, and lightweight, having a density about one-half that of conventional aggregates. Their material is used as aggregate in roof tile, concrete block, and structural concrete, and in other ways in horticulture, highway construction, and 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 246,000 t (271,000 st) in 2012, an increase of approximately 20% over 2011. This production had an estimated value of roughly \$3.2 million, also a 20% increase over 2011 because 2011 prices remained unchanged (USGS, 2013a). In descending order of production, the four producers were (1) Sunroc Corporation, (2) United States Gypsum Company, (3) Diamond K Gypsum, Incorporated, and (4) Nephi Gypsum. Two wallboard plants are located in Utah, both near the town of Sigurd in Sevier County. The plant operated by United States Gypsum was active in 2012 (figure 6), but the plant operated by Georgia Pacific remains idle due to economic considerations. Utah gypsum is primarily used in the manufacturing of wallboard. Lesser amounts of raw gypsum are used by regional cement companies as an additive to retard the setting time of cement, and by the agriculture industry as a soil conditioner.

## Exploration and Development Activity

Industrial minerals exploration and development in Utah follows two separate paths. High-value-per-ton commodities like potash respond to the strength of the world economy because of their ability to withstand shipping charges, and the demand for these products has grown over the past decade. Low-value-per-ton commodities like sand and gravel are developed and used locally and are more reflective of the vigor of the regional market.

## Potash

In 2012, industrial minerals exploration activity increased in Utah, principally for potash. Potash exploration has focused on such diverse sources as deep evaporites in the Paradox Basin, and shallow brines in the Sevier Lake

playa and in the 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 briefly summarized in table 3.

## Halloysite

The Dragon mine is situated in the southern Main Tintic mining district of Juab County in central Utah (figure 7). The Dragon mine had historic production of approximately 1.2 million t (1.3 million st) of halloysite, at least 450,000 t (500,000 st) of iron ore, and an uncertain tonnage of oxidized silver-gold ore. Halloysite  $[Al_2Si_2O_5(OH)_4]$  is a specialty kaolinite-group clay with a unique micro-tubular structure. The iron ore is an exceptionally pure goethite-hematite gossan, probably developed after 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, Incorporated owns the Dragon property (38 patented lode claims) including the Dragon pit, has a large mine permit, and is working toward reopening the mine as an underground operation to produce halloysite and possibly an iron-oxide pigment by-product. Recent drill results from 80 shallow holes in the Dragon pit indicate a measured resource of about 501,200 t (552,500 st) of 64.8% halloysite (Applied Minerals, Incorporated, 2011). Underground mine development is currently in progress.

## Gilsonite

Gilsonite is experiencing increased interest from the oil and gas industry due to its use as a lost circulation additive in well drilling fluids and cementing slurries. Gilsonite sales to the oilfield market have increased over 150% since 2009. In response to increased demand, American Gilsonite Company has initiated a significant investment program to open new mines, explore new mine development methods, and develop strategic long-term reserves. The American Gilsonite Company expects to double its current production capacity in the near future (O’Driscoll, 2012).

## URANIUM

### Production and Value

Energy Fuels Resources was responsible for all uranium produced in Utah during 2012, having acquired Denison Mines Corporation during the year, including its producing Daneros, Beaver, and Pandora mines. Energy Fuels Resources produced approximately 251,000 kg (553,000 lb) of uranium oxide ( $U_3O_8$ ) having a value of about \$30.9 mil-

**Table 3.** Potash exploration projects in Utah, 2012.

Property	Deposit Type	County	Company	Progress
Blawn Wash	Alunite alteration	Beaver	Potash Ridge Corporation	In-place measured and indicated resource of 620 million tons of about 30% alunite; completed 84 drill holes with more planned for 2013; completed preliminary economic assessment
Bounty Potash	Great Salt Lake Desert, shallow brine	Box Elder	Mesa Exploration Company	Acquired 66,048 acres; historic resource of 5.14 million tons KCl; seeking exploration permits
Crescent Junction	Paradox Basin, deep evaporites	Grand	Pinnacle Potash International	Acquired 13 state leases, completed 1 hole
Green River	Paradox Basin, deep evaporites	Grand	American Potash LLC (Magna Resources Ltd.)	Project area 50,950 acres; received drilling permits on state leases; drilling planned for early 2013
Paradox Basin	Paradox Basin, deep evaporites	Grand	Universal Potash Corporation	Applied for 29,000 acres
Salt Wash	Paradox Basin, deep brines and evaporites	Grand	Mesa Exploration Company	Applied for 21,184 acres
Whipsaw	Paradox Basin, deep brines and evaporites	Grand	Mesa Exploration Company	Applied for 17,968 acres
White Cloud	Paradox Basin, deep brines and evaporites	Grand	Mesa Exploration Company	Applied for 35,510 acres
Sevier Lake	Sevier (Dry) Lake, shallow brine	Millard	Peak Minerals Inc. (EPM Mining Ventures Inc.)	124,221 acres under lease; 426 exploration holes in 2011 and 2012; in-place measured and indicated resource of 32.5 million tons of potassium sulfate; working on preliminary feasibility study
Hatch Point	Paradox Basin, deep evaporites	San Juan	K20 Utah LLC (Potash Minerals Limited)	90,190 acres in Hatch Point area; completed 3 deep holes on SITLA tracts in 2011; seeking federal exploration permit
Lisbon Valley	Paradox Basin, deep evaporites	San Juan	Potash Green Utah LLC (North American Potash Developments Inc.)	State leases and federal prospecting permit applications totaling 31,061 acres in Lisbon Valley, completed 1 hole
Monument	Paradox Basin, deep evaporites	San Juan	Paradox Basin Resources Corp.	Holdings include 104,467 acres of federal land under application, state leases, and private land

lion, at an average realized price of \$123.08/kg (\$55.83/lb) (Energy Fuels, 2013). The uranium and byproduct vanadium ore was shipped to Energy Fuel's White Mesa mill (figure 6), located about 10 km (6 mi) south of Blanding in San Juan County, and processed into  $U_3O_8$  and  $V_2O_5$ . The value of uranium produced in Utah in 2012 increased about 4.7% over the value in 2011, and was due to an approximate 8.9% increase in production over 2011, despite a slightly lower selling price. Uranium spot prices peaked at about \$115/kg (\$52/lb) early in 2012, reached a low of around \$90/kg (\$41/lb) late in the year, but recovered at year's end to about \$99/kg (\$45/lb) (Energy Fuels, 2013).

### Exploration and Development Activity

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 past decade with spikes to \$300/kg (\$136/lb) in June 2007 and lows of under \$100/kg (\$45/lb) in 2009–2010. The spot price rebounded to \$161/kg (\$73/lb) in early 2011, only to fall below \$110/kg (\$50/lb) again following the Fukushima nuclear power plant disaster in March 2011. Uranium exploration and development in Utah has waxed and waned with these spot price



fluctuations. Long-term contract  $U_3O_8$  prices, in contrast, have remained relatively constant at approximately \$132/kg (\$60/lb). In the last few years of low prices, the uranium industry in Utah has undergone a period of property/company consolidation with Energy Fuels acquiring most of the promising uranium mines and prospects in Utah. Energy Fuels, Incorporated and Denison Mines Corporation announced on April 16, 2012, that they had signed a letter agreement for Energy Fuels to acquire the U.S. assets of Denison Mines in exchange for Energy Fuels shares.

The continuing low  $U_3O_8$  prices (under \$100/kg [\$45/lb]) resulted in a halt to all production from uranium mining operations in Utah in early 2013. The White Mesa mill is continuing operations on ore from higher grade uranium

breccia pipe deposits across the state line in the Arizona Strip, north of the Grand Canyon.

The following paragraphs report the major uranium events in Utah in 2012, and table 4 summarizes miscellaneous uranium activities.

### Energy Fuels, Incorporated

Energy Fuels, Incorporated owns six permitted uranium mines in Utah as well as the 1800 t per day (2000 st/day), dual-circuit (uranium-vanadium) White Mesa mill near Blanding. The mill processes both uranium-vanadium ore and an alternate feed waste material. The mill began oper-

**Table 4.** *Uranium projects in Utah, 2012.*

Property	District	County	Company	Progress
San Rafael	San Rafael River	Emery	Energy Fuels, Inc.	Indicated resource: 758,050 tons @ 0.23% $U_3O_8$
Frank M	Henry Mountain	Garfield	Uranium One, Inc.	Resource: 1.5 M tons @ 0.12% $U_3O_8$
North Wash	Henry Mountain	Garfield	Vane Minerals Plc.	29 holes drilled, including 9.5 ft @ 0.36% $U_3O_8$
Tony M/Bullfrog	Henry Mountain	Garfield	Energy Fuels, Inc.	Permitted resource: 1.527 M tons @ 0.24% $U_3O_8$
Whirlwind	Beaver Mesa	Grand	Energy Fuels, Inc.	Permitted resource: 656,000 lb $U_3O_8$
Thompson Project	Thompson	Grand	Energy Fuels, Inc.	Acquired 6672 acres
Rim-Columbus	Dry Valley	San Juan	Energy Fuels, Inc.	Permitted resource: 660,000 lb $U_3O_8$
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 $U_3O_8$
North La Sal	La Sal	San Juan	Vane Minerals Plc.	Acquired 80 acres
Pandora/Snowball/Beaver	La Sal	San Juan	Energy Fuels, Inc.	On stand-by: 1.2 M lb $U_3O_8$ reserve
La Sal #2	Lisbon Valley	San Juan	Laramide Resources Ltd.	Resource: 808,000 tons @ 0.167% $U_3O_8$
Lisbon mine area	Lisbon Valley	San Juan	Mesa Exploration Corp.	22 holes (~60,000 ft), including 3.5 ft @ 0.28% $U_3O_8$
North Alice Extension	Lisbon Valley	San Juan	Vane Minerals Plc.	Resource: 43,000 tons @ 0.14% $U_3O_8$
Velvet	Lisbon Valley	San Juan	Uranium One, Inc.	Permitted resource: 580,000 lb $U_3O_8$
Sage Plain (Calliham-Sage)	Ucolo	San Juan	Energy Fuels, Inc.	Resource: 642,971 tons @ 0.22% $U_3O_8$ and 1.39% $V_2O_5$
Daneros (Lark Royal)	White Canyon	San Juan	Energy Fuels, Inc.	On stand-by: 740,000 lb $U_3O_8$ inferred resource
Geitus	White Canyon	San Juan	Energy Fuels, Inc.	Resource: 40,000 ton @ 0.3% $U_3O_8$

ating on stockpiled ore from Energy Fuels-owned mines in 2008, and began accepting ore from other companies for toll milling in 2009. The mill has the capacity to produce about 1.36 million kg (3 million lb) of  $U_3O_8$  and 2 million kg (4.5 million lb) of  $V_2O_5$  annually. Uranium recoveries typically average over 90%.

In late 2006, the Pandora mine, in the eastern La Sal mining district (figure 7), San Juan County, became the first Utah uranium producer since 1991. Energy Fuels' Pandora mine shipped about 110 t per day (120 st/day) 110 km (70 mi) south to the White Mesa mill, until it was put on standby in 2013. In 2012, the Pandora mine produced about 27,846 t (30,695 st) of ore.

In 2009, the Beaver mine, 3 km (2 mi) west of the Pandora mine was reopened. The Beaver mine was also producing about 150 t per day (160 st/day) until its closure in October 2012. The La Sal district uranium ores are hosted in the Upper Jurassic Salt Wash Member of the Morrison Formation. In 2012, the Snowball and connected Beaver Shaft is credited with about 40,502 t (44,646 st) of ore.

The Daneros mine in the White Canyon mining district (figure 7), San Juan County, was permitted in May 2009, development began in July, and production started in December 2009. Denison acquired the mine in June 2011, and it was sold to Energy Fuels in April 2012. The Daneros ore body had an estimated resource of 130,000 t (143,000 st) at 0.26%  $U_3O_8$  hosted by the basal Shinarump Conglomerate Member of the Upper Triassic Chinle Formation and also contains about 1% copper (Peters, 2012). The mine is accessed by twin declines, developed by room and pillar methods, and had ramped up production to 130 t per day (140 st/day). Ore is shipped 100 km (62 mi) to the White Mesa mill. In 2012, the Daneros produced 35,868 t (39,538 st) averaging about 0.22%  $U_3O_8$ .

Energy Fuels' Henry Mountains Complex (Tony M mine and Bullfrog properties) in the Shootaring Canyon district, Garfield County, and Rim mine in the Dry Valley (East Canyon) district of San Juan County, are both on standby awaiting higher uranium prices. Both the Shootaring and Dry Valley district ore bodies are hosted in the Upper Jurassic Salt Wash Member of the Morrison Formation.

In 2007, Energy Fuels acquired the Energy Queen mine in the La Sal district (figure 7), San Juan County, and began rehabilitation. The mine has an estimated resource of 87,300 t (96,250 st) of ore averaging 0.32%  $U_3O_8$  and 1.24%  $V_2O_5$ , with access via an existing 229-m-deep (750-ft) lined shaft (Peters, 2011a). The Whirlwind mine on Beaver Mesa straddles the Utah-Colorado border about 45 km (28 mi) northeast of Moab in Grand County. The property began limited production in 2009, but has been on standby since then. The Whirlwind mine has a measured resource of 134,057 t (147,798 st) of ore averaging 0.27%  $U_3O_8$  and

0.88%  $V_2O_5$  (Peters, 2011b). Both the Energy Queen and Whirlwind uranium ores are hosted in the Upper Jurassic Salt Wash Member of the Morrison Formation.

Energy Fuels acquired the Deep Gold and Down Yonder uranium resources in the San Rafael River mining district (figure 7), Emery County, in 2011, through a merger with Titan Uranium, Incorporated. The San Rafael project has an estimated resource of about 1.58 million kg (3.49 million lbs)  $U_3O_8$  (Gatten, 2011).

In 2012, Energy Fuels obtained a 100% interest in the Sage Plain project in the Ucolo uranium district (figure 7), San Juan County. Sage Plain has calculated a measured and indicated resource of 583,194 t (642,971 st) at 0.22%  $U_3O_8$  and 1.39%  $V_2O_5$  (Peters, 2011c). This project encompasses the historic Calliham and Sage mines.

## Uranium One, Incorporated

Uranium One, Incorporated acquired the uranium assets of the U.S. Energy Corporation in 2006 and Energy Metals in 2007. These assets in the Lisbon Valley district (figure 7) included the Velvet mine with an indicated resource of about 64,260 t (70,850 st) averaging 0.41%  $U_3O_8$  and 0.57%  $V_2O_5$  (Beahm and Hutson, 2007). The Velvet has the highest grade uranium resource known in the state and is hosted in the Lower Permian Cutler Group sandstone. Other Uranium One assets include the large, albeit low-grade, Frank M underground uranium resource and nearby inactive 680 t per day (750 st/day) Shootaring Canyon (Ticaboo) uranium mill, both in the Henry Mountains, Garfield County.

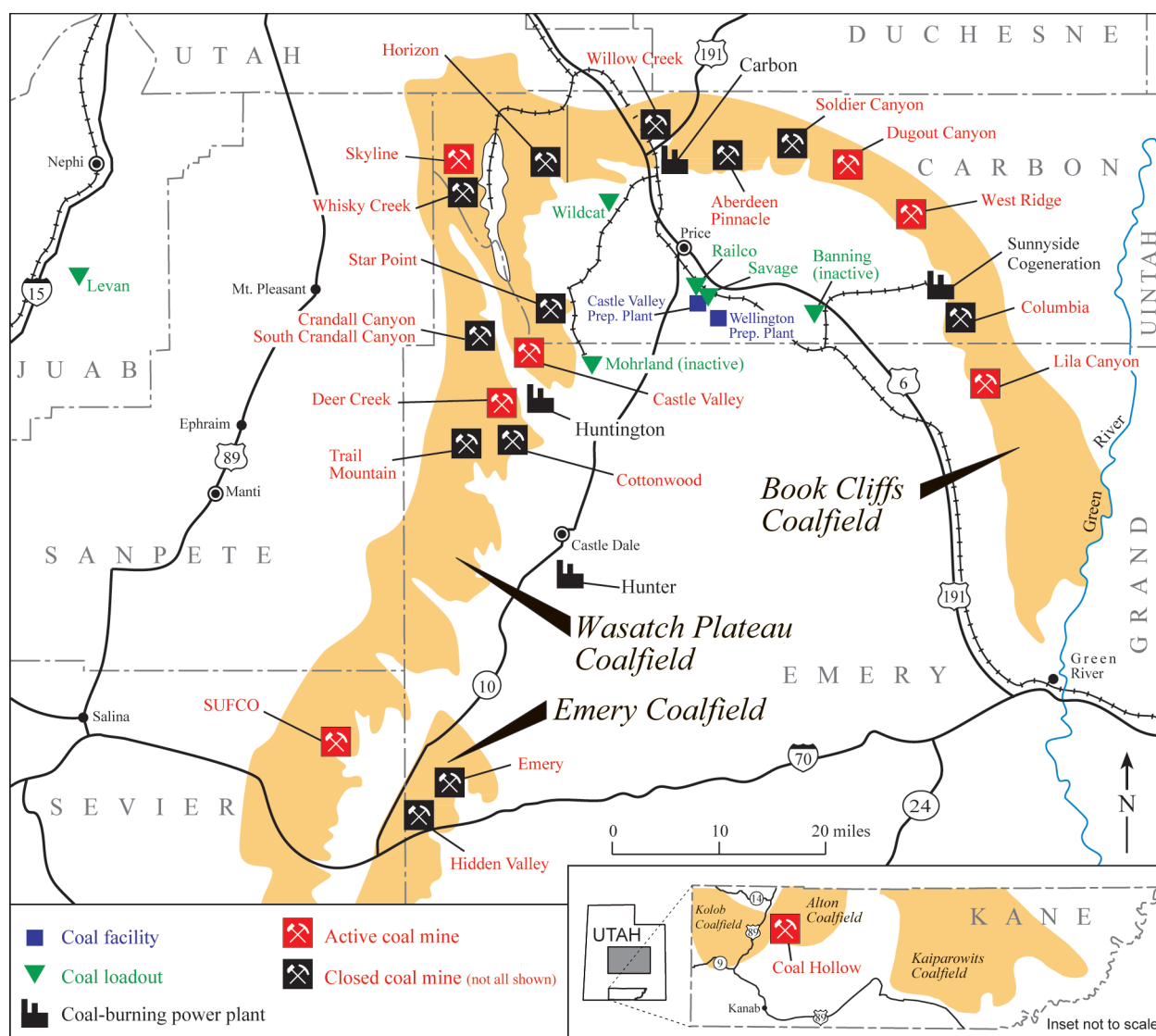
## Laramide Resources Limited

Laramide Resources is working to develop the La Sal deposit in the Lisbon Valley mining district (figure 7), the largest uranium-producing district in Utah. The La Sal deposit was initially developed by Homestake Mining Company in the Permian Cutler Formation sandstone beneath the Triassic-hosted ores of the main Big Indian uranium belt. The estimated La Sal resource is approximately 725,000 t (800,000 st) of 0.17%  $U_3O_8$ .

## COAL

### Production and Values

Seven Utah coal operators produced 15.6 million t (17.2 million st) of coal valued at \$614 million from eight underground and one surface mine in 2012 (figures 5 and 10). This production was 2.6 million t (2.9 million st) (14.5%) less than in 2011. The majority of this decrease was attributed to the Canyon Fuel mines and the West Ridge mine



**Figure 10.** Location and status (at time of printing) of Utah's coal mines and associated facilities.

lowering production because of decreasing demand (table 2). In addition, the Horizon mine was idled in mid-2012 and eventually shut down. Demand for coal declined from a regulatory-induced drop in demand for coal-generated electricity, as well as a 2012 catastrophic generator failure at the Intermountain Power Plant (IPP) near Delta, Utah. Even with IPP returning to full capacity, production in 2013 is expected to again decrease to 14.7 million t (16.3 million st) valued at \$606 million. The largest decline in production in 2013 will come at the Dugout Canyon mine as longwall production ceased in late 2012 and mining will only continue with one continuous miner, reducing the mine's production to just 454,000 t (500,000 st) for the year.

In 2012, the majority of Utah coal, 11.0 million t (12.1 million st), was produced from the Wasatch Plateau coalfield, with 4.1 million t (4.5 million st) coming from mines in the Book Cliffs coalfield and 517,000 t (570,000 st) from

the Coal Hollow mine in the Alton coalfield. The majority of Utah coal, 84.2% (13.1 million t, 14.4 million st) was produced from federal land, while only 4.6% (710,000 t, 783,000 st) was from state-owned land. In July 2011, the Deer Creek mine's state-owned Mill Fork coal tract reverted back to federal ownership after a 20.2 million t (22.3 million st) coal production threshold was reached. This reversion dramatically increased the amount of coal produced on federal land in 2012, from 48.0% in 2011 to 84.2% in 2012. The remainder was produced from private (10.8%, 1.7 million t [1.9 million st]) and county (0.4%, 68,000 t [75,000 st]) lands.

Existing Utah 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 to natural gas over coal-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 strict air quality 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. The city has already stated that it will no longer purchase power from IPP after its current power purchase agreement expires in 2027, unless 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 13.6 to 18.1 million t (15 to 20 million st) range for the foreseeable future.

The total amount of Utah coal distributed to market in 2012 totaled 15.2 million t (16.8 million st), slightly less than the total coal produced for the year. The vast majority of Utah's coal, 86%, goes to the electric utility market. As a result of the slowed U.S. economy and new regulation limiting coal-fired generation, demand for coal to produce electricity decreased, resulting in a 66% drop in the demand for Utah coal at electric generating facilities, from 19.5 million t (21.5 million st) in 2008 to 11.9 million t (13.1 million st) in 2012. The economic recession and low natural gas prices also slowed demand for Utah coal in the industrial sector, with deliveries dropping to 2.0 million t (2.2 million st) in 2012, the lowest level since 1987. Coal deliveries in 2013 are expected to remain in the 15 million t (17 million st) range, correlating with lower overall production. However, the last few years have seen an uptick in the amount of Utah coal being exported to other countries, in particular the Asian coal market. Demand for coal in Asia is strong, but Utah operators will need increased access to port facilities to allow this market to replace slowing domestic demand.

For detailed statistics on Utah's coal industry (including information previously published in the annual Utah coal report), please refer to the abundant 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, Incorporated – Murray Energy Corporation

**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 366-m-long (1200 ft) rock slopes and began development work in the Sunnyside coal bed, producing 65,000 t (72,000 st) of coal in 2010. Development work continued in 2011 and 2012, with total coal production reaching 142,000 t (157,000 st) and 275,000 t (304,000 st), respectively. Coal production is expected to remain at the 227,000 t (250,000 st) level until longwall mining commences, possibly in 2015. At full capacity, the exact timing of which depends on the future coal market, the

mine could employ up to 200 people and produce up to 4.1 million t (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 4.0 m (13 ft) thick. Up to 42 million t (46 million st) of recoverable coal is under lease. Approximately 29 million t (32 million st) of additional reserves on 4200 acres of federal land to the south has recently been nominated for leasing by UtahAmerican.

### West Ridge Resources, Incorporated – 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 2.3 million t (2.6 million st) of coal in 2012, down from 3.2 million t (3.6 million st) produced in 2011, due mainly to difficult mining conditions and a weak coal market. Production in 2013 is expected to increase slightly to 2.5 million t (2.8 million st). UtahAmerican estimates that the West Ridge mine has 6.4 million t (7.1 million st) of recoverable coal under lease, which will accommodate longwall production only until 2015.

### Canyon Fuel Company – Arch Coal

Arch Coal, Inc. recently sold Canyon Fuel Company, which includes all three Utah mines, to Bowie Resources, LLC. The transaction is expected to close in the third quarter of 2013. Bowie, based in Louisville, Kentucky, will own the mines in a joint venture with Galena Private Equity Resources Fund, a unit of Amsterdam-based commodity trader Trafigura Beheer BV. Trafigura will sell the venture's coal production.

**Dugout Canyon mine:** The Dugout Canyon mine, located in the Book Cliffs coalfield, produced 1.4 million t (1.6 million st) of coal from the Gilson bed in 2012, down significantly from the 2.2 million t (2.4 million st) produced in 2011. Dugout Canyon's longwall was shut down in December 2012 due to a weak coal market. Consequently, production in 2013 is expected to only reach about 454,000 t (500,000 st) with one continuous miner. Canyon Fuel estimates that the Dugout Canyon mine has 12.1 million t (13.3 million st) of recoverable coal remaining under lease.

On a positive note, the Dugout Canyon mine completed 933,150 man-hours (31 consecutive months), including all of 2011 and 2012, without a single Mines Safety and Health Administration (MSHA) reportable injury. In addition, the mine completed 1,329,445 man-hours (39 consecutive months) without a single lost time injury. This exemplary safety record resulted in the Dugout Canyon mine being awarded several very prestigious safety awards including:

- The National Mining Association Sentinels of Safety Award (2011) for large underground coal mines. This award is the longest standing, most



prestigious safety award in the nation.

- The Arch Coal Inc. Presidential Safety Award for 2011 and 2012 (co-winners with the SUFCO mine) for the safest underground coal mine within Arch Coal.
- The Rocky Mountain Coal Mining Institute's Safest Large Operator award (2011) for underground coal mines.
- The State of Utah's "Safe Operator of the Year Award" for 2011.
- The Utah Manufacturing "Award of Excellence" for 2012.

**Skyline mine:** Canyon Fuel Company's Skyline mine, located in the Wasatch Plateau coalfield, is currently mining in the Lower O'Connor "A" bed on their North lease (Winter Quarters lease) in Carbon County. Production from this bed decreased significantly in 2012 to 1.8 million t (2.0 million st) as longwall equipment was moved to the North Lease, but should rebound to 2.0 million t (2.2 million st) in 2013. Canyon Fuel estimates that 16.4 million t (18.1 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 23 to 27 million t (25 to 30 million st) of reserves.

**SUFCO mine:** SUFCO is Utah's largest coal producer and the eighth-largest producing underground coal mine in the United States (2011 data). It is also the only active coal mine in Sevier County. SUFCO produced 5.2 million t (5.7 million st) of coal in 2012 from the upper Hiawatha bed, 15% less than in 2011 and 40% less than record high production of 7.2 million t (7.9 million st) achieved during 2006. Demand for SUFCO coal diminished in 2012 due to a 6-month outage at the coal-burning IPP. With IPP back online, production at SUFCO is expected to increase slightly to 5.4 million t (5.9 million st) in 2013. Canyon Fuel estimates that roughly 38.3 million t (42.2 million st) of reserves remain under lease in the upper and lower Hiawatha beds. On a separate note, the new Quitcupah road is currently under construction and should be finished by the end of 2013. This new road will significantly reduce coal haulage time for trucks heading for the Emery County power plants.

**Greens Hollow tract:** Canyon Fuel has nominated the federal Greens Hollow tract for leasing, 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. A National Environmental Protection Act (NEPA) plan is currently being formulated. The Greens Hollow tract is thought to contain approximately 66 million t (73 million st) of reserves within the lower Hiawatha bed.

## CONSOL Energy

**Emery mine:** CONSOL Energy's Emery mine, its only mine in the western United States, produced about 0.9 million t (1 million st) annually from the Ferron Sandstone I bed from its opening in 2005 through 2010. However, CONSOL indefinitely idled the mine in December 2010, citing lack of coal demand. The mine is currently up for sale.

## Rhino Energy

**Castle Valley mines:** Rhino Energy purchased the Bear Canyon mines, formerly owned by C.W. Mining (Co-Op), in 2010, and during bankruptcy proceedings renamed the mines Castle Valley. No coal was produced from the property in 2010, but Rhino produced 537,000 t (592,000 st) in 2011 using continuous miner machines in the Tank bed. Full-scale production with two continuous miners increased production in 2012 to 907,000 t (1.0 million st). Rhino estimates that 7.1 million t (7.8 million st) of reserves still exist on leased land, but roughly 45.9 million t (50.6 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 increased to 3.0 million t (3.3 million st) in 2012 and is expected to decrease slightly in 2013 to 2.7 million t (3.0 million st). From the inception of mining on the Mill Fork lease to July 2011, this tract was state-owned; however, its reversion back to federal ownership will greatly decrease Utah's production of state-owned coal. Production in the Blind Canyon bed at Mill Fork was completed in mid-2010, and shifted back to the Hiawatha bed. There are roughly 10.9 million t (12 million st) of coal remaining in the Hiawatha in this area.

## 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 Company, which is a subsidiary of Arch Coal, Inc., also the owner of Canyon Fuel Company. Two coal leases were issued, one for 3320 ha (8204 acres) covering lands within the 1998 land exchange Cottonwood Coal Tract and the other for 243 ha (600 acres) within an adjacent SITLA section. In mid-2011, the Cottonwood lease was transferred to Fossil Rock Fuels, a subsidiary of PacifiCorp and Rocky Mountain Power, as part of a settlement of litigation between the two companies. 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 leases is estimated to equal 44 million t (49 million st). Fossil Rock Fuels will soon begin a three-year exploration program on

the newly acquired Cottonwood lease.

## America West Resources, Incorporated

**Hidden Splendor Resources, Incorporated – Horizon mine:** The Horizon mine, located approximately 18 km (11 mi) west of Helper in the Wasatch Plateau coalfield, was idled in July of 2012 after producing 191,000 t (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 operation sealed. In February 2013, the company filed for bankruptcy with a subsequent bankruptcy sale in April. The mine failed to sell, but Bowie Resources, who just recently acquired the Canyon Fuels Company, expressed interest in purchasing America West's coal supply contracts. In addition, a Rhino Resource Partners affiliate bought some of the mining equipment. Before the mine closed, America West estimated that 14.5 million t (16 million st) of coal remained on leased land.

## Alton Coal Development

**Coal Hollow mine:** In 2011, Alton Coal Development began production at a new coal mine in the Alton coalfield in southern Utah's Kane County. Surface-mining production on the company's private property totaled 365,000 t (403,000 st) for 2011 and increased to 517,000 t (570,000 st) in 2012. Production in 2013 is expected to increase again to about 635,000 t (700,000 st). Full production at the Coal Hollow mine could total 1.8 million t (2.0 million st) per year, but 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 10.9 million t (12.0 million st) of recoverable coal, while reserves on the surrounding federal mining areas are estimated between 32 and 36 million t (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 9% ash. As overburden increases, the company eventually plans to switch to underground mining.

tuted 86% of Utah's total fuel production value in 2012. Oil and gas values decreased about \$113 million (3%) in 2012 compared to 2011. Although the volume and value of oil was up, the value of gas was down due to a lower average annual price. Utah's oil price has risen 53% between 2005 and 2012, while production has risen by 81%; during that same period the natural gas price has decreased by 62%, while marketed gas production has risen by 61%. Thus, gas and oil are following different market trends with oil production following price upward, but gas production increasing in spite of falling prices. In 2013, gas prices are expected to rise slightly as gas consumption increases. Utah's 2012 oil and gas production came from 11,124 producing wells (4253 oil wells and 6871 gas wells), an increase from the 10,283 producing wells in 2011 (3814 oil and 6469 gas).

Oil's contributions were the largest to the total value of fuel production in Utah in 2012, with a value of \$2.50 billion, about \$336 million (14%) more than in 2011. Duchesne, Uintah, San Juan, and Sevier Counties, in decreasing order of production, were the four largest oil-producing counties in Utah in 2012, and when combined, contributed for about 98% of the total state production volume. The five largest producing oil fields in 2012, Monument Butte (Duchesne and Uintah), Greater Aneth (San Juan), Altamont (Duchesne), Bluebell (Duchesne and Uintah), and Covenant (Sevier), accounted for about 62% of Utah's total oil production.

Gas contributed the second-largest share of the overall value of fuel commodities produced in Utah during 2012, with an estimated value of \$1.33 billion, a \$449 million (25%) decrease from 2011. Uintah, Carbon, Duchesne, and Emery Counties, in decreasing order of production, were the four largest gas-producing counties in Utah in 2012, and when combined, contributed about 95% of the total state gas-production volume. The five largest producing gas fields in 2012, Natural Buttes (Uintah), Drunkards Wash (Carbon), Peters Point (Carbon), Nine Mile Canyon (Carbon), and Helper (Carbon), accounted for 74% of the total gas production, but Natural Buttes alone accounted for about 56% of Utah's 2012 gas production.

## CRUDE OIL AND NATURAL GAS

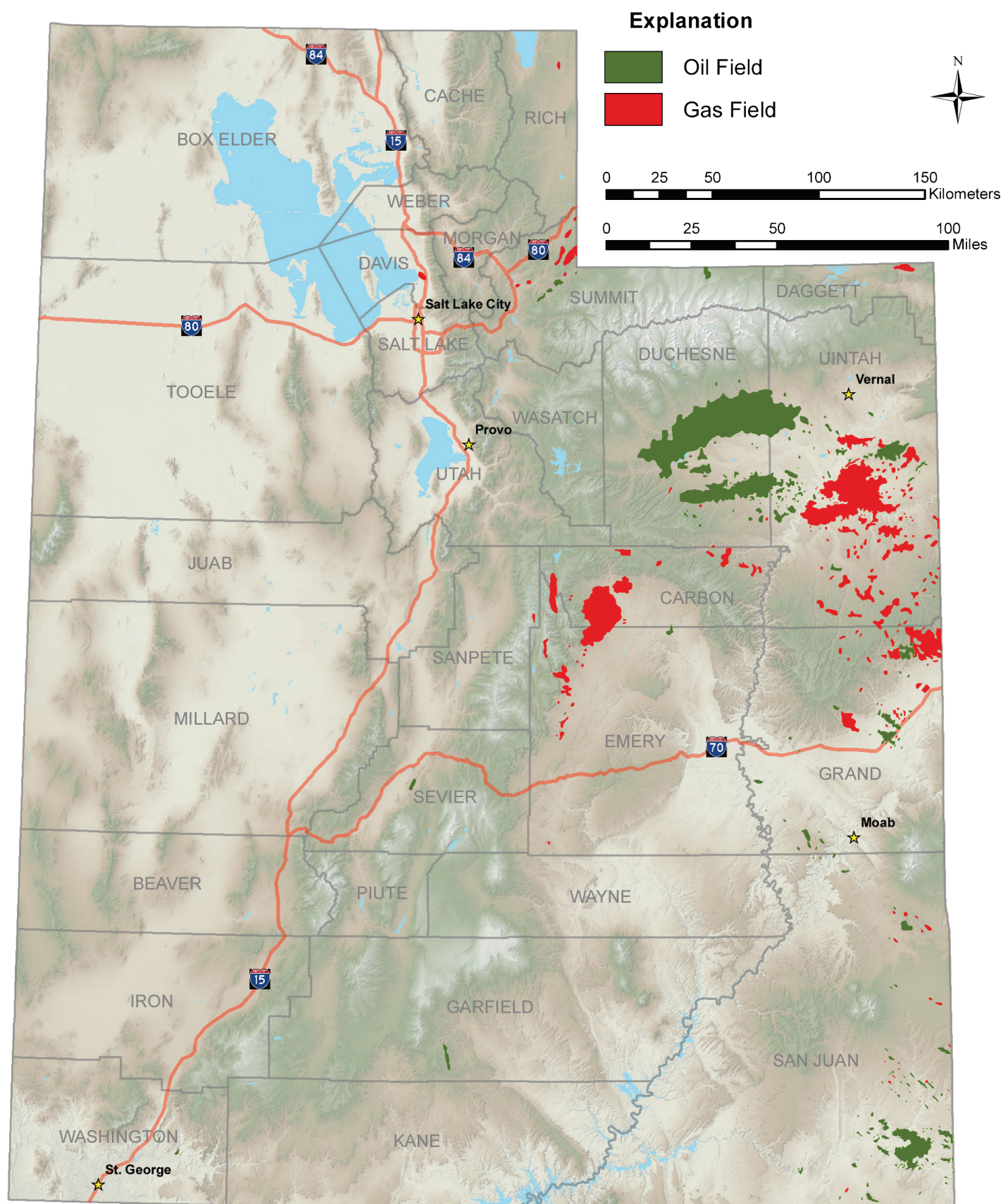
### Production and Values

Most of the statistical data presented here on oil and gas were found on the DOGM website at <http://oilgas.ogm.utah.gov/index.htm>. At an estimated value of \$3.83 billion, oil and gas production was the largest contributor to the total value of fuel commodities produced in Utah during 2012, with 4.8 million m<sup>3</sup> (30.3 million barrels [bbls]) of oil and 13.9 billion m<sup>3</sup> (490.4 billion ft<sup>3</sup>) of gas produced from Utah's oil and gas fields (figure 11). Oil and gas consti-

### Exploration and Development Activity

Utah experienced an increase in oil and gas exploration and development activity in 2012, and, in comparison with 2011, the number of wells permitted rose 39% from 1516 to 2103, and the number of wells started (spudded) increased 11% from 989 to 1099. The county with the most oil and gas exploration and development activity was Uintah County with 1213 new well permits and 631 well spuds; the second most active was Duchesne County with 745 new well permits and 419 well spuds; and the third most active was Carbon County with 93 new well permits and 18 well spuds. These top three counties accounted for





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



about 97% of the new well permits and well spuds in Utah in 2012. The 1055 new oil and gas wells completed during 2012 were an increase from the 846 completed in 2011. The new oil and gas wells completed in 2012 consist of 822 new wells within established field boundaries, 118 wells drilled outside of an existing field boundary with the intent of extending the field boundary, and 115 wild-cat wells drilled in unproven areas. Of the 1055 new wells, 557 (53%) were oil wells, 456 (44%) were gas wells, and 10 (1%) were service wells (injection or disposal wells). Not all of the 1055 new wells drilled in 2012 were productive and 22 (2%) were plugged and abandoned. The ratio of new oil wells to new gas wells drilled has increased in the past few years in response to the high oil prices and depressed gas prices, and this trend will continue until gas prices recover to a more attractive level.

## UNCONVENTIONAL FUELS – OIL SHALE AND OIL SAND

### Exploration and Development Activity

#### Oil Shale

The upper Green River Formation in Utah's Uinta Basin hosts one of the largest deposits of oil shale in the world. Estimated in-place resources total 207 billion m<sup>3</sup> (1.3 trillion bbls) of oil (USGS Oil Shale Assessment Team, 2011) with approximately 12 billion m<sup>3</sup> (77 billion bbls) as a potentially economic resource (Vanden Berg, 2008). The richest oil shale horizon in Utah is the Mahogany zone (figure 12), where in individual beds oil in the rock can reach



**Figure 12.** Mahogany zone oil shale beds in the upper Green River Formation.



up to 334 L/t (80 gal/st). The Mahogany zone is 21 to 31 m (70–100 ft) thick and is accessible via extensive exposures along the eastern and southern flanks of the basin.

## Operators

The outcrop accessibility, low dip, and shallow cover of Utah's richest oil shale deposits make surface/underground mining and surface retort the preferred technology for recovering the oil from the shale. Currently, two companies are pursuing oil shale development in Utah: Enefit American Oil and Red Leaf Resources.

Enefit American Oil is an Estonian company that acquired 100% of OSEC (Oil Shale Exploration Company), including all 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 an 8000 m<sup>3</sup> per day (50,000 bbls/day) oil shale operation, consisting of a surface/underground mine (which would process nearly 27 million t [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 stages, with plans for 4000 m<sup>3</sup> per day (25,000 bbls/day) by 2020 and 8000 m<sup>3</sup> per day (50,000 bbls/day) by 2024. Current 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.

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 technology referred to as the Ecoshale technology. Basically, the process involves surface mining a pit, lining the pit with an impermeable clay layer, placing the oil shale back in the "capsule" with a series of pipes, covering the capsule with clay and top soil, and retorting the shale in the capsule via hot air circulating through the pipes. Reclamation can commence while the capsule is still retorting the shale. This process has already been tested on the pilot scale level and the company is currently seeking a large mine permit to test the process on a larger scale. Commercial plans are to produce 1500 m<sup>3</sup> per day (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, the 5th largest oil and gas company in the world. Total will fund an 80% share of the early production system expenses, which are estimated at approximately \$200 million.

## Oil Sand

North America has the greatest oil sand resources in the world, the majority of which are in Canada. Utah's oil sand resource, though small in comparison to that of Canada, is the largest in the United States. Utah's oil sand depos-

its contain 2.2 to 2.4 billion m<sup>3</sup> (14–15 billion bbls) of in-place oil, with an additional estimated resource of 3.7 to 4.4 billion m<sup>3</sup> (23–28 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 52 to over 647 km<sup>2</sup> (20 to over 250 mi<sup>2</sup>), as many as 13 pay zones, gross thickness ranging from 3 to more than 305 m (10 to more than 1000 ft), and overburden thickness ranging from zero to over 152 m (500 ft).

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, and 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.

## Operators

U.S. Oil Sands is the most active company seeking to develop Utah's oil sand resources. The company has several state 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 over 180 wells on their leases to prove up the resource. The company recently acquired all necessary permits and is currently trying to raise the capital needed to begin operation.

One of Utah's most promising oil sand deposits is located along Asphalt Ridge near Vernal, Utah. Several companies in the past have tried to develop oil sand operations in the area, but in 2012 no commercial activity took place besides limited extraction for use as road pavement.

## NEW MINERALS INFORMATION

The following recent publications provide new information on the energy and mineral resources of Utah. 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>.

Massoth (2012) expanded a well database and prepared maps of salt cycles and potash zones of the Paradox Basin,

Utah. Rupke and McDonald (2012) provided a Great Salt Lake brine chemistry database for 1966–2011. Currie and others (2012) reported on the reservoir character of the Lower Cretaceous Cedar Mountain and Dakota Formations, northern Uinta Basin, Utah. Vanden Berg and others (2013) provided a geological characterization of the Birds Nest aquifer, Uinta Basin, Utah, as an assessment of the aquifer's potential as a saline water disposal zone for the oil and gas industry. Boden and others (2012) compiled production and values and exploration and development activity for Utah's extractive resource industries for 2011.

The UGS maintains a comprehensive repository for Utah energy and mineral data at <http://geology.utah.gov/emp/energy-data>. 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.

## RECLAMATION AND THE ENVIRONMENT

The U.S. Department of Energy (DOE) and the State of Utah agreed to move the 10.8 million t (11.9 million st) of Atlas uranium mill tailings located along the Colorado River near Moab. The tailings will be moved 48 km (30 mi) north to a site near Crescent Junction. DOE transports the tailings by rail to a 100-ha (250 acre) disposal cell excavated in the impermeable Cretaceous Mancos Shale. The project began shipping tailings in April 2009 and had moved nearly 4.5 million t (5 million st) by the end of 2011 with an additional 807,618 t (890,246 st) moved in 2012 (Donald Metzler, DOE, written communication, April 2013). DOE hopes to finish the cleanup by 2019.

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## REFERENCES

- Alexander, T.G., 2006, Generating wealth from the earth 1847–2000, *in* Whitley, C., editor, *From the ground up—the history of mining in Utah*: Logan, Utah State University Press, p. 37–57.
- Applied Minerals, Incorporated, 2011, Applied Minerals provides updated resource statement of its Dragon Mine property: Online, [http://appliedminerals.tempwebpage.com/images/uploads/the-dragon-mine/Final\\_-\\_Applied\\_Minerals\\_IncResource\\_Statement.pdf](http://appliedminerals.tempwebpage.com/images/uploads/the-dragon-mine/Final_-_Applied_Minerals_IncResource_Statement.pdf), accessed April 2013.
- Beahm, D.L., and Hutson, H.J., 2007, Velvet mine uranium project, San Juan County, Utah, U.S.A.: unpublished Canadian national instrument (NI) 43-101 technical report prepared for Energy Metals Corp., 35 p.
- Boden, T., and Tripp, B.T., 2012, Gilsonite veins of the Uinta Basin, Utah: Utah Geological Survey Special Study 141, 50 p., 1 plate, CD.
- Boden, T., Vanden Berg, M.D., Krahulec, K., Tabet, D., and Gwynn, M., 2012, Utah's extractive resource industries 2011: Utah Geological Survey Circular 115, 27 p.
- CML Metals, 2012, CML shareholders update January 12, 2012: Online, [http://www.palladonventures.com/s/PressReleases.asp?ReportID=501429&\\_Type=Press-Releases&\\_Title=Palladon-Ventures-CML-Update](http://www.palladonventures.com/s/PressReleases.asp?ReportID=501429&_Type=Press-Releases&_Title=Palladon-Ventures-CML-Update), accessed April 2013.
- Currie, B.S., McPherson, M.L., Hokanson, W., Pierson, J.S., Homan, M.B., Pyden, T., Schellenbach, W., Purcell, R., and Nicklaus, D., 2012, Reservoir characterization of the Lower Cretaceous Cedar Mountain and Dakota Formations, northern Uinta Basin, Utah: Utah Geological Survey Open-File Report 597, 34 p., 5 plates, CD.
- Energy Fuels, 2013, Energy Fuels FY-2012 annual results: Online, [http://www.energyfuels.com/\\_resources/news/nr\\_2012\\_12\\_21.pdf](http://www.energyfuels.com/_resources/news/nr_2012_12_21.pdf), accessed April 2013.
- Gatten, O.J., 2011, NI 43-101 technical report on the San Rafael uranium project, Emery County, Utah: unpublished Canadian national instrument (NI) 43-101 technical report prepared for Energy Fuels, Incorporated, 55 p.
- Gwynn, M., Krahulec, K., and Vanden Berg, M.D., 2011, Utah mining 2010: Utah Geological Survey Circular 114, 21 p.
- Katsura, K.T., and Armitage, A., 2012, Technical report on the Gold Springs property, Utah/Nevada, USA: unpublished Canadian national instrument (NI) 43-101 technical report prepared for High Desert Gold Corporation, 98 p.
- Krahulec, K., 2006, Utah mining timeline, *in* Bon, R.L., Gloyn, R.W., and Park, G.M., editors, *Mining districts of Utah*: Utah Geological Association Publication 32, p. 1–5.
- Krahulec, K., 2011, Sedimentary rock-hosted gold and silver deposits of the northeastern Basin and Range, Utah, *in* Steininger, R., and Pennell, B., editors, *Great Basin evolution and metallogeny: Geological Society of Nevada 2010 Symposium Volume I*, p. 31–62.
- Krahulec, K., and Briggs, D.F., 2006, History, geology, and production of the Tintic mining district, Juab, Utah,

- and Tooele Counties, Utah, in Bon, R.L., Gloyd, R.W., and Park, G.M., editors, *Mining districts of Utah*: Utah Geological Association Publication 32, p. 121–150.
- Massoth, T.W., 2012, Well database and maps of salt cycles and potash zones of the Paradox Basin, Utah: Utah Geological Survey Open-File Report 600, 18 p., 21 plates, CD.
- O'Driscoll, M., 2012, Oilfield minerals outlook—hot and gritty in Houston: *Industrial Minerals*, July 2012, no. 538, p. 10–12.
- Office of Natural Resources Revenue, 2013, Office of Natural Resources Revenue statistical information: Online, <http://statistics.onrr.gov/ReportTool.aspx>, accessed May 2013.
- Peters, D.C., 2011a, Updated technical report on Energy Fuel Resources Corporation's Energy Queen property, San Juan County, Utah: unpublished Canadian national instrument (NI) 43-101 technical report prepared for Energy Fuels, Incorporated, 36 p.
- Peters, D.C., 2011b, Updated technical report on Energy Fuel Resources Corporation's Whirlwind property, Mesa County, Colorado and San Juan County, Utah: unpublished Canadian national instrument (NI) 43-101 technical report prepared for Energy Fuels, Incorporated, 34 p.
- Peters, D.C., 2011c, Technical report on Colorado Plateau Partners LLC's Sage Plain project, San Juan County, Utah and San Miguel County, Colorado: unpublished Canadian national instrument (NI) 43-101 technical report prepared for Colorado Plateau Partners, 55 p.
- Peters, D.C., 2012, The Daneros mine project, San Juan County, Utah, U.S.A.: unpublished Canadian national instrument (NI) 43-101 technical report prepared for Energy Fuels, Incorporated, 33 p.
- Rio Tinto, 2013, Rio Tinto 2012 annual report: Online, [http://www.riotinto.com/reportingcentre2012/pdfs/rio\\_tinto\\_2012\\_annual\\_report.pdf](http://www.riotinto.com/reportingcentre2012/pdfs/rio_tinto_2012_annual_report.pdf), accessed April 2013.
- Rupke, A., and McDonald, A., 2012, Great Salt Lake brine chemistry database, 1966–2011: Utah Geological Survey Open-File Report 596, 7 p.
- Selway, J., Baker, J., Hodder, S., Robinson, J., 2012, Independent technical report and estimated resources for TUG property, Utah, United States: unpublished Canadian national instrument (NI)#43-101 technical report prepared for West Kirkland Mining Inc., dated July 13, 2012, 140 p.
- SRK Consulting, 2009, NI 43-101 preliminary economic assessment Palladon Ventures Ltd. Iron Mountain, Iron County, UT: unpublished Canadian national instrument (NI) 43-101 technical report prepared for Palladon Ventures Ltd., 158 p.
- Stowe, C.H., 1975, Utah mineral industry statistics through 1973: *Utah Geological and Mineral Survey Bulletin* 106, 121 p.
- Tietz, P.G., Prens, N., Wood, J., and Gast, T., 2011, Technical report on the Burgin Extension deposit—preliminary economic assessment, Burgin Project, East Tintic mining district, Utah County, Utah, USA: unpublished Canadian national instrument (NI) 43-101 technical report prepared for Andover Venture Inc. and Chief Consolidated Mining Co., 152 p.
- U.S. Bureau of Economic Analysis, 2013, Gross domestic product by state: Online, <http://www.bea.gov/regional/gsp/>, accessed May 2013.
- U.S. Energy Information Administration, 2013a, Quarterly coal report, 2011: Online, <http://www.eia.gov/coal/production/quarterly/>, accessed May 2013.
- U.S. Energy Information Administration, 2013b, Crude oil production, 2011: Online, [http://www.eia.gov/dnav/pet/pet\\_crd\\_crdn\\_adc\\_mbbbl\\_a.htm](http://www.eia.gov/dnav/pet/pet_crd_crdn_adc_mbbbl_a.htm), accessed May 2013.
- U.S. Energy Information Administration, 2013c, Natural gas annual, 2011: Online, <http://www.eia.gov/naturalgas/annual/>, accessed May 2013.
- U.S. Geological Survey, 2013a, U.S. Geological Survey mineral commodity summaries 2013: Online, <http://minerals.usgs.gov/minerals/>, accessed April 2013.
- U.S. Geological Survey, 2013b, Crushed stone and sand and gravel in the fourth quarter 2012: Online, [http://minerals.usgs.gov/minerals/pubs/commodity/stone\\_crushed/mis-2012q4-stonc.pdf](http://minerals.usgs.gov/minerals/pubs/commodity/stone_crushed/mis-2012q4-stonc.pdf), accessed April, 2013.
- U.S. Geological Survey Oil Shale Assessment Team, 2011, Oil shale resources in the Eocene Green River Formation, greater Green River Basin, Wyoming, Colorado, and Utah: U.S. Geological Survey Data Series 69-DD, no pagination.
- Utah Geological Survey, 2006, Utah—100 years of exploration: *Utah Geological Survey Public Information Series* 71.
- Vanden Berg, M.D., 2008, Basin-wide evaluation of the uppermost Green River Formation's oil-shale resource, Uinta Basin, Utah and Colorado: *Utah Geological Survey Special Study* 128, 19 p., 8 plates, CD.
- Vanden Berg, M.D., Lehle, D.R., Carney, S.M., Morgan, C.D., 2013, Geological characterization of the Birds Nest aquifer, Uinta Basin, Utah—assessment of the aquifer's potential as a saline water disposal zone: *Utah Geological Survey Special Study* 147, 47 p., 31 plates, CD.
- Walker, G.L., and Smith, S.D., 1989, Survey methods and statistical summary of nonfuel minerals: *Bureau of Mines Minerals Yearbook* 1988, v. 2, p. 1–44.
- Wilson, A., McMahon, F. and Cervantes, M., 2013, Survey of mining companies 2012/2013: Online, <http://www.fraserinstitute.org/uploadedFiles/fraser-ca/Content/research-news/research/publications/mining-survey-2012-2013.pdf>, accessed April 2013.





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